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वाटर मिस्ट अग्नि सुरक्षा पद्धतियाँ — पद्धति डिजाइन, संस्थापन और चालू करना — रीति संहिता

(पहला पुनरीक्षण)

Water Mist Fire Protection Systems — System Design, Installation and Commissioning — Code of Practice

(First Revision)

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Fire Fighting Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first published in 2004. The fire protection of a building or plant must be considered as a whole. While water mist fire protection systems form only a part, though an important one, of the available facilities, it should not be assumed that their adoption necessarily remove the need to consider supplementary measures, such as the provision of portable fire extinguishers or mobile appliances for first aid or emergency use or measures to deal with special hazards. Water mist systems have been found to be effective for the suppression or extinguishment of a wide variety of the exposed and shielded Class B hydrocarbon pool fires and for combinations of incidental Class A and Class B fires. Water mist systems have also demonstrated their effectiveness on some Class A fires, including insulated electrical cable fires.

This revision has been brought out to incorporate the experience gained in use of the standard since its first publication. The following are the major modifications in this revision:

a) Terminologies have been brought up-to-date;
b) Classifications of mist, nozzle types, associate components and safety requirements have been elaborated;
c) Design guidelines for water mist sprinkler systems, water mist nozzles, deluge systems, water and atomizing gas supply, and water and propellant/atomizing gas supply have been covered in detail;
d) Hydraulic calculations have been suggested for validating the design of mist systems; and
e) Review, commissioning and maintenance have been modified and updated.

This standard provides minimum requirements for the design, supply, installation, testing, commissioning and maintenance of water mist systems. Each risk has its own size, configuration and character with respect to nature of fire and its propagation. Hence, it may not be possible to provide uniform regulations with respect to design of water mist system.

System acceptance as a whole requires submission of relevant fire test report(s) or listing documents as well as the manufacturer’s design, supply, installation, operation and maintenance manual along with application to the local authorities concerned for acceptance of the system.

This standard guides for the protection of both industrial and non-industrial occupancies and also performance criteria for personnel (life safety) and property protection.

The water supply for the system shall preferably use potable water. Where sea water is used, provisions shall be made to allow a thorough flushing of the system piping with fresh water after functioning. Other sources can also be used, provided they are treated from time to time to remove all suspended matters and impurities.

The effectiveness of water mist is ascertained by fire testing on a hazard of the same configuration and general hazard type. Presently, there is no design procedure that would allow extrapolation of test results to different hazards or different enclosure configurations.

Full detailed test reports or certificate are required along with the drawings to demonstrate the adequacy of the system design. Tests shall be conducted at recognized test laboratories as per the relevant standards. In the absence of test reports validating the design of water mist system from recognized third party laboratories, the system shall not be accepted for installation.

The composition of the Committee responsible for the formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of specified value in this standard.

Indian Standard

WATER MIST FIRE PROTECTION SYSTEMS — SYSTEM DESIGN, INSTALLATION AND COMMISSIONING — CODE OF PRACTICE

(First Revision)

1 SCOPE

1.1 This standard specifies minimum requirements for design, supply, installation, testing, commissioning, maintenance and the criteria for acceptance of fixed land-based water mist systems.

1.2 This standard does not provide any requirements for the protection of ships, in aircraft, on vehicles and mobile fire appliances or for below ground systems in the mining industry.

1.3 This standard does not cover protection requirements against explosion.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards given in Annex A.

3 DEFINITIONS

For the purpose of this standard, the definitions given below shall apply.

3.1 Additive — Chemical or mixture of chemicals or gases, intentionally introduced into a water mist system for one or more of the following purposes:

a) Enhancement of or compliance with fire protection requirements;
b) Corrosion protection; and
c) Frost protection.

3.2 Assumed Maximum Area of Operation (AMAO) — Theoretical maximum surface area for which the operation of automatic nozzles during a fire is assumed to be operated.

NOTE — This system applies to water mist systems with automatic nozzles. The principle is similar to that in automatic sprinkler system and can also be expressed in terms of 'maximum number of nozzles that can operate simultaneously at a minimum residual pressure'.

3.3 Atomizing Media — Compressed air or inert gases that produce water mist by expansion and mechanical mixing with water.

3.4 Automatic — Performing a function without the necessity of human intervention.

3.5 Automatic Water Mist Nozzle — A thermo-sensitive device designed to react at a pre-determined temperature by automatically releasing water mist and distributing it in a specified pattern and quantity over a designated area that operates independently of other water mist sprinkler nozzles by means of a detection/activation device built into the nozzle.

3.6 Container — A cylinder or other vessel used to store liquids or gases.

3.7 Container Discharge Valve — A valve directly connected to a container which, when actuated, releases extinguishing agent into the distribution piping.

3.8 Corrosion Resistant Material — A material, such as bronze, brass, stainless steel and the like which has a low propensity for corrosion when used in anticipated application.

3.9 Deluge System — A water mist system using nozzles attached to a piping system that are connected to a water supply through a valve and where all nozzles discharge simultaneously.

3.10 Deep Seated Fire — A deep-seated fire is the one that gets established beneath the surface of a fibrous or particulate material. This may result from flaming combustion at the surface or from ignition within the mass of the fuel. It is characterized by glowing embers and smoldering rather than flaming due to reduced oxygen levels. Smoldering combustion may then progress slowly through the mass.

3.11 Density — System application rate, which may be expressed in the following two ways:

a) Discharge density of the flow from the system in respect of the area of the risk and expressed as litre per min/m^2.
b) Flux density of the flow from the system in respect of the volume of the risk and expressed in l/min/m^3.

3.12 Directional Valve — A device for controlling the passage of the extinguishing agent from a supply manifold, directing it to pre-selected area(s) of protection.

3.13 Discharge Duration — Accumulated time (in min) during which fire fighting medium is applied at the rated pressure.

3.14 Discharge Time — Time interval (in s) between the first appearance of extinguishing agent at the nozzle and the time at which the discharge becomes predominantly gaseous or ceases.

3.15 Distribution System — All pipe work and fittings downstream of any container valve, deluge valve or other control assembly.

3.16 Dump Valve — An automatic valve installed on the discharge side of a positive displacement pump to relieve pressure prior to the pump driver reaching operating speed.

3.17 D_{vf} — A drop diameter such that the cumulative volume, from zero diameter to this respective diameter, is the percentage of the corresponding sum of the total distribution.

NOTE — D_{v50} is the volume median diameter, that is, 50 percent of the total volume of liquid is in drops of smaller diameter and 50 percent is in drops of larger diameter.

3.18 Enclosure — A totally or partially confined volume.

3.19 Fire Compartment — A volume that is defined by fire rated separations.

3.20 Fire Control — The limitation of the growth of a fire by pre-wetting adjacent combustibles and controlling ceiling gas temperatures to prevent structural damage.

3.21 Fire Extinguishment — The complete suppression of a fire until there are no burning combustibles.

3.22 Fire Suppression — The sharp reduction of the rate of heat release of a fire and the prevention of re-growth.

3.23 Flash-Over — A stage in the development of contained fire in which all exposed surfaces reach auto-ignition temperatures more or less simultaneously and fire spreads rapidly throughout the space.

3.24 Light Hazard Occupancy — An occupancy where the quantity and/or combustibility of contents is low and where fires with relatively low rates of heat release are expected.

NOTE — Light hazard occupancies can include occupancies (non-storage and non-manufacturing) having conditions similar to apartments, churches, clubs, educational buildings, hospitals, institutional facilities, libraries (except large stack rooms), museums, offices, data processing areas without open storage of information media, residential buildings, restaurant seating areas, theaters and auditoriums (excluding stages and prosceniums), and the like.

3.25 Machinery Space — These areas include auxiliary turbine rooms, oil pumps, oil reservoirs, fuel filters, gear boxes, drive shafts, lubrication skids and diesel/petrol engine rooms where the hazard is a combustible liquid. Quantity of combustibles and liquids shall be as per the listing restrictions from the recognized test laboratories.

3.26 Manual — Requiring human intervention to accomplish a function.

3.27 Monitoring — The supervision of the operating integrity of an electrical, mechanical, pneumatic or hydraulic control feature of a system.

3.28 Nominal Size (*DN*) — A numerical designation of size which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

3.29 Nozzle — A special purpose device, containing one or more orifices, designed to produce and deliver a water spray meeting either the definition of water mist or meeting the specific requirements of an approved water mist fire test protocol.

3.30 Operating Device — Any component involved between actuation and release of agent.

3.31 Ordinary Hazard Occupancy — An area where the quantity and combustibility of contents is moderate to high and where fires with moderate and high rates of heat release are expected.

3.32 Pre-burn Time — Time from the ignition of the fire source till the operating pressure or design flow is available at the hydraulically most remote nozzle.

3.33 Pressure — Various terms associated with pressures are given below.

3.33.1 *Maximum Nozzle Operating Pressure* — Highest pressure that the nozzle distribution system is designed for.

3.33.2 *Maximum System Operating Pressure* — Highest pressure that any one system component is subject to. Typically this would be the pressure available in cylinder storage at the maximum operating temperature or pressure at the pump discharge.

3.33.3 *Maximum System Pressure* — Highest pressure available from the pressure source. Typically this would be the pressure setting of the pressure relieving device.

3.33.4 *Operating Pressure* — The pressure at which a nozzle is intended to operate.

3.33.5 *Rated Working Pressure* — Maximum pressure at or below which all components shall operate trouble free.

3.33.6 *Working Pressure* — The maximum anticipated static (non-flowing) pressure applied to the system components exclusive of surge pressures.

3.33.7 *Standby Pressure* — The pressure maintained in a water mist system under a non-fire or standby condition.

3.34 Pressure Reducing Valve — A valve designed for the purpose of reducing the downstream water or gas pressure to a specific value under both flowing (residual) and non-flowing (static) conditions.

3.35 Pressure Regulating Device — A device designed for the purpose of reducing, regulating, controlling or restricting system pressure. Examples include pressure reducing valves, pressure control valves and pressure restricting devices.

3.36 Primary Protection — A water mist system is considered as a primary protection system (when installed) for a part/portion of an occupancy, which is otherwise protected by a sprinkler system. Duration of water supply shall be at least equal to that required for sprinkler system. Required quantity of water shall be calculated based on system hydraulics.

3.37 Propellant — Compressed gas used as a prime mover to push water out of storage vessels, through pipe networks, or through distribution components.

3.38 Relief Valve — A device that allows diversion of liquid or gas in order to limit excess pressure in a system.

3.39 Residential Area — A building in which sleeping accommodation is provided for normal residential purposes and also includes lodging and rooming houses, 1 or 2 family private dwelling, apartment houses, hotels, dormitory, apartments, condominiums, and the like.

3.40 Response Time Index (RTI) — A measure of nozzle sensitivity expressed in units of $tu^{0.5}$ where, t is the time constant of the heat responsive element in units of seconds and u is the gas velocity expressed in m/s. RTI can be used in combination with the conductivity factor (C) to predict the response of a nozzle in fire environments defined in terms of gas temperature and velocity *versus* time.

3.41 Single Fluid System — A water mist system utilizing a single fluid to supply each nozzle.

3.42 Special Protection System — A fire extinguishing system that is installed for the protection of areas where water mist and other limited agent supply systems, such as dry chemical or clean agent systems would be acceptable methods of protection.

NOTE — The agent supply shall be adequate for a minimum of:

a) twice the time to extinguish a worst case test fire in an accepted fire test scenario, or

b) the total time to shut down process equipment including the time it takes for surface temperatures to drop below auto-ignition temperature of the fluid or 10 min, whichever is greater.

3.43 Standard Orientation — The orientation in which the air flow is perpendicular to the axis of nozzle's waterway and plane of the frame arms, when provided, in order to produce shortest response time.

3.44 Supervision — In waterbased fire protection systems, a means of monitoring system status and indicating abnormal conditions.

3.45 Total Compartment Application System — A system designed to discharge water mist to protect all hazards in an enclosure.

3.46 Twin Fluid System — A water mist system in which water and an atomizing media are supplied to the system. They can be single pipe systems, where the two fluids are supplied to the nozzles through the same pipe, and double pipe systems where the fluids are separately supplied and are mixed at the nozzles.

3.47 Unloader Valve — A type of relief valve that is designed to relieve excess flow in case of volumetric pumps.

3.48 Water Mist — A water spray for which the $Dv_{0.90}$, for the flow weighted cumulative volumetric distribution of water droplets, is less than 1 000 µ at the minimum design operating pressure of the water mist nozzle.

4 GENERAL

4.1 This standard addresses the use of fine water sprays for the efficient control, suppression or extinguishment of fires using limited volumes of water. Properly designed water mist systems can be effective on both liquid fuel (Class B) and solid fuel (Class A) fires.

Research indicates that fine (that is, smaller than 400 µ) droplets are essential for extinguishment of Class B fires, although larger drop sizes are effective for Class A combustibles, which benefit from extinguishment by fuel wetting. For this reason, the definition of water mist in this standard includes sprays with $Dv_{0.90}$ of up to 1 000 µ.

4.2 This standard's interpretation of 'water mist' includes some water sprays used in IS 15105 and IS 15325 some sprays produced by standard sprinklers/spray nozzles operating at high pressure, as well as light mists suitable for greenhouse misting and HVAC humidification systems. This range in drop size distribution is so broad that some important differences in the performance of sprays with finer different distributions are not distinguished.

4.3 The relationship between drop size distribution and extinguishing capacity of a water mist is complex. In general, very fine particles enhance heat absorption and generation of water vapour. With liquid (Class B) fuels, too many 'large' drops could agitate the surface of the fuel and increase burning intensity. On the other hand, larger drops could assist the spray to penetrate and wet charred, smoldering Class A fuels. Larger drops could also entrain finer drops in their wake and improve the transport of much smaller drop sizes into the seat of the fire.

4.4 Drop size distribution alone does not determine the ability of a spray to suppress or extinguish a given fire. Factors such as fuel properties, enclosure effects (which are a function of ventilation and heat confinement), spray flux density and spray velocity (momentum) are all involved in determining the effectiveness of a water mist in fire suppression or extinguishment.

The momentum of an element of spray is the product of its velocity and the mass of dispersed water droplets (that is, the mass flow rate). It must be stressed that the term velocity implies direction as well as speed.

It is the momentum of a mist in a particular direction, relative to the direction of flow of the hot fire gases that enhances cooling and suppression effectiveness. Opposing directional flows bring about turbulent mixing, hence improved cooling. Therefore, all three variables, drop size distribution, flux density, and velocity are involved in determining the ability to suppress or extinguish a fire in a given scenario.

4.5 A water mist system is a fire protection system using very fine water sprays (that is, water mist). The very small water droplets allow the water mist to control, suppress or extinguish fires by cooling of the flame and fire plume, oxygen displacement by water vapour, and radiant heat attenuation.

4.6 Water mist systems have been found effective in controlling, suppressing, or extinguishing certain types of fires. This standard addresses the use of fine water sprays to achieve all the above characteristics in process of extinguishment. Wherever, water mist systems were found effective, they can be accepted provided they have been tested and demonstrated for the particular application and class.

4.7 Classification of Water Mist Systems

4.7.1 Based on working pressure, water mist systems are classified into low pressure, intermediate pressure and high pressure systems as defined in **4.7.1.1, 4.7.1.2** and **4.7.1.3**. The pressure range is of significance for the component selection.

4.7.1.1 *Low pressure system*

A water mist system where the distribution piping is exposed to pressures of 12.1 bar or less.

4.7.1.2 *Intermediate pressure system*

A water mist system where the distribution system piping is exposed to pressures greater than 12.1 bar but less than 34.5 bar.

4.7.1.3 *High pressure system*

A water mist system where the distribution system piping is exposed to pressures of 34.5 bar or greater.

4.7.2 *Based on Particle Size Distribution*

As a means of allowing distinctions to be made between coarser and finer sprays across the 1 000 µm spectrum of this standard's definition of water mist, it is useful to subdivide mist into class 1, 2 or 3 water mist, according to the droplet size distribution as defined in **4.7.2.1, 4.7.2.2** and 4.**7.2.3**. The defining boundaries for the three classifications are illustrated in Fig. 1.

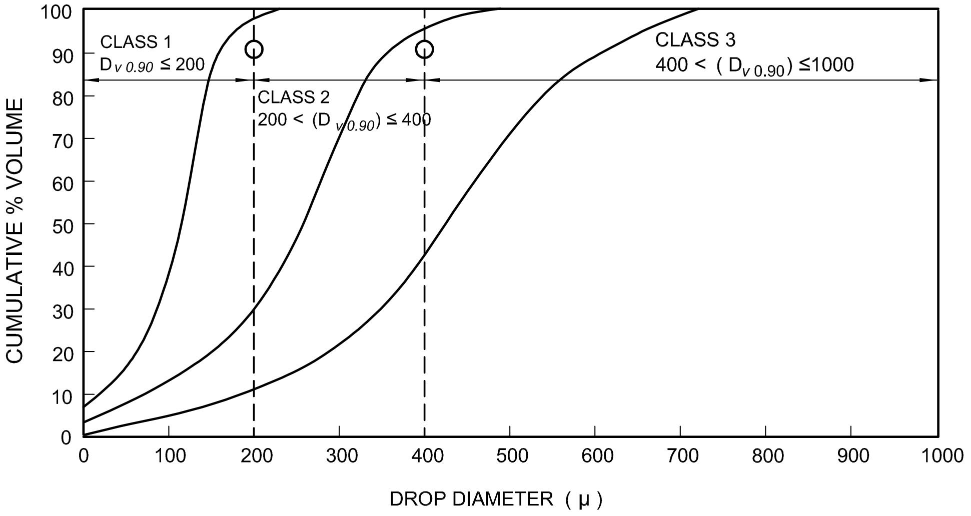

Fig. 1 Classification of Water Mist According to Droplet Size

4.7.2.1 *Class 1 mist*

90 percent of the volume of water is contained in droplets less than 200 µm in diameter. This represents the finest water mist.

4.7.2.2 *Class 2 mist*

90 percent of the volume of water is contained in droplets with diameter in 200 - 400 µm range.

4.7.2.3 *Class 3 mist*

90 percent of the volume of water is contained in droplets with diameter in 400 - 1 000 µm range.

4.7.3 The drop size distribution of a spray does not uniquely define its suitability for a given application. It is inseparable from the spray direction relative to the fire plume, its velocity and flux density. The momentum of an element of spray is the product of its velocity (which includes direction as well as speed) and the mass of dispersed water droplets.

Therefore, all three variables that is, drop size distribution, flux density and momentum are involved in determining the ability to suppress or extinguish a fire in a given scenario.

4.8 Water mist systems also offer potential benefits for many specialized applications, where it would be difficult to find a suitable traditional option. These systems may also be used as an alternative to traditional sprinklers and deluge systems for those types of applications (cleared after fire tests by recognized laboratories), particularly when available water supplies are limited or when the application of water must be restricted.

NOTE — Due to the presence of larger drops, higher mass flow rates are easier to achieve with Class 2 sprays than with Class 1 mist. The larger drops are not so large as to be ineffective on liquid fuel fires. However, considerable surface wetting occurs with sprays in this range; therefore a Class 2 mist is also likely to be effective on fires involving ordinary combustibles. Class 3 water mists are typically generated by intermediate pressure, small orifice sprinklers, impingement nozzles of various sorts and fire hose fog nozzles.

4.9 System Types

A water mist distribution system is a system that is connected to a water supply and equipped with one or more nozzles capable of delivering water mist. A water mist system shall meet the performance requirements of its intended application.

4.9.1 *Pre-engineered Systems*

A water mist system having predetermined flow rates, nozzle pressures and volumes, and spray densities of water mist. These systems have the specific pipe sizes, maximum and minimum pipe lengths, flexible hose, number of fittings, and number and types of nozzles.

4.9.2 *Engineered System*

A water mist system where, as required by the accepting authority, individual calculation and design shall be done to determine the system flow rates, pipe sizes, area or volume protected by the system, discharge density of water mist, number and types of nozzles, and nozzle placement.

4.9.3 *Deluge System*

A water mist system using open spray nozzles attached to a piping system that is connected to a water supply through a valve that is opened either manually or by means of a detection system installed in the same area as the spray nozzles. When the valve opens, water flows into the piping system and discharges through all spray nozzles attached to the system. There are different types of deluge type water mist systems including:

a) *Total flooding system* — A system designed to discharge water mist to simultaneously protect all hazards in an enclosure.
b) *Zoned application system* — A system designed to protect hazards in a pre-determined portion of an enclosure.
c) *Local application system* — A system arranged to discharge directly on an object or hazard in an enclosed or un-enclosed or open outdoor hazards.

4.9.4 *Dry System*

A water mist system using sealed nozzles attached to a piping system containing air, nitrogen or inert gas under pressure, the release of which (as from an opening of sealed nozzle) allows the water supply pressure to open a dry-pipe valve. The water then flows into the piping system and out through any nozzles that have opened.

4.9.5 *Pre-action System*

A water mist system using sealed nozzles attached to a piping system containing air that might or might not be under pressure with a supplemental detection system installed in the same areas as the mist nozzles. The actuation of the detection system opens a valve and the water then flows into the piping system and out through any nozzles that have opened.

4.9.6 *Wet System*

A water mist system using sealed nozzles attached to a piping system containing water and connected to a water supply so that water discharges immediately from nozzles that are operated by the heat from a fire.

4.10 Nozzles

The nozzles covered in this standard are intended to generate water mist to control, extinguish or suppress fire and consist of the following types:

a) *Automatic* — A thermo-sensitive device designed to react at a pre-determined temperature by automatically releasing water mist and distributing it in a specified pattern and quantity over a designated area that operates independently of other nozzles by means of a detection/activation device built into the nozzle.

b) *Coated* — A nozzle that has a factory applied coating for corrosion protection.

c) *Concealed* — A recessed nozzle with a ceiling cover plate.

d) *Flush* — A nozzle in which all or part of the body, including the inlet thread, is mounted above the lower plane of the ceiling.

e) *Fusible element* — A nozzle that opens under the influence of heat by the melting of a component.

f) *Glass bulb* — A nozzle that opens under the influence of heat through pressure resulting from expansion of the enclosed fluid.

g) *Hybrid* — Nozzles capable of operation using both automatic and non-automatic means.

h) *Multiple orifice* — A nozzle having two or more outlet orifices.

j) *Open (spray nozzle)* — A nozzle without a thermo-sensitive element which discharges water mist.

k) *Pendent* — A nozzle that is arranged in such a way that water mist is directed downward by striking a distribution plate or by nozzle orientation.

m) *Pilot* — A heat actuated nozzle which also controls the flow of water to one or more connected nozzles.

n) *Recessed* — A nozzle of which all or part of the body, other than the inlet thread, is mounted within a recessed housing.

p) *Sidewall* — A nozzle intended for installation near a wall and ceiling interface and designed to discharge water outward from, and onto adjacent walls.

q) *Upright* — A nozzle that is arranged in such a way that water mist is initially directed upwards against a distribution plate.

r) *Sealed* — A nozzle that operates independently of other nozzles by means of a detection and activation device built into the nozzle.

5 OBJECTIVES OF WATER MIST SYSTEM

Water mist extinguishing systems can be used to protect life and property from consequences of fire through suitable design, supply, installation and commissioning.

5.1 The performance of the water mist system is enumerated hereunder:

a) *Fire control* — Fire control which can be described in detail by one or more of the following:

    1) A reduction in the thermal exposure to the structure where the primary objective is to maintain the structure's integrity of the building (for example, to prevent flashover).

    2) A reduction in the threat to occupants where the primary objective is to minimize loss of life.

    3) A reduction in fire related characteristic such as a heat release rate, fire growth rate or spread to adjacent objects, dilution of smoke and flammable vapour.

b) *Cooling* — When turning into vapour, water absorbs more heat than any other fire fighting agent.

c) *Inerting* — In evaporation, the water volume expands over 1 700 times displacing oxygen. Evaporation rate of water depends on the free surface area, which can be increased by splitting the bulk volume into droplets: the smaller the droplets are in the form of water mist, the faster is the evaporation and the more efficient is the cooling and inerting.

d) *Blocking radiant heat* — Water in the form of mist has an additional and extremely useful fire fighting mechanism that no other agent has that is, a dense cloud of micro-droplets effectively absorbs and scatters the heat radiated by the fire, protecting the immediate surroundings.

e) *Fire suppression* — Sharp reduction in the rate of heat release of a fire and the prevention of fire re-growth.

f) *Fire extinguishment* — The complete suppression of a fire until there are no burning combustibles.

5.2 Application of water mist system are enumerated hereunder.

Water mist systems are used for a wide range of performance objectives including the following:

a) Fire extinguishment,

b) Fire suppression,

c) Fire control,

d) Temperature control, and

e) Exposure protection.

5.3 Typical applications of water mist systems, but not limited to what is mentioned above, are as follows:

a) Buildings like hotels, residentials, offices, churches, art galleries, libraries, theaters, heritage buildings, hospitals, high rise buildings, etc.

b) Computers and data processing equipment and control rooms.

c) Electronic equipment including telecommunication equipment.

d) Electrical hazards, such as transformers, switches, circuit breakers, and rotating equipment cable runs in tunnels, etc.

e) Aircraft hangers, cargo bay and crew cabin compartment.

f) Defence applications (land) like aircraft hangers, command centres, maintenance and training facilities.
g) Transportation sectors like road and train tunnels, metro stations, terminals and rolling stock (passenger, machinery and technical areas).
h) Local protections like rooms, vaults, enclosed machines, containers, storage tanks and bins.
j) Industrial applications (local protection) like machinery spaces, engines using flammable fuels, gas turbines, fryers, gas jet fires, etc.
k) Cooking equipment (local protection) using cooking oils and fats.
m) Spray booths (painting lines) and engine test cells of automotive industry.
n) Conveyor belts.
p) Flammable liquid storage and processing areas and combustible solids.
q) Marine and navy applications like vessels, submarines, cargo ships, ship bays, etc.
r) Offshore facilities like platforms and production facilities.

NOTE — Unless the system is demonstrated and approved for the type of protection by any recognized national/international laboratories along with certification for the type of occupancy configuration following fire tests, water mist systems may not be treated as acceptable protection. Further, no extrapolation of test results shall be made.

5.4 A system may be used to protect more than one risk area by means of directional valves. Where two or more areas could be simultaneously involved in a fire by reason of their proximity, such areas shall be protected by either,

a) individual systems designed to allow simultaneous operation, or
b) a single system sized and arranged to discharge simultaneously on all potentially involved hazards.

5.5 Some advantages of the water mist systems over the other water based protection systems are given below:

a) Water requirement for fire suppression is minimum.
b) Water damage to properties is minimum.
c) Faster fire suppression/cooling characteristics.
d) Three dimensional nature of fire suppression mechanism.
e) Suitability for suppression of liquid fires.
f) Ease of installation.
g) Leakage from pipe lines are very minimum in view of usage of stainless steel pipes and fittings.
h) Non-toxic for humans.
j) No decomposition products during the process of extinguishment.
k) Minimum downtime following an extinguishment process.

5.6 Limitations of Water Mist Systems

These systems shall not be used for direct application to materials that react with water to produce significant amounts of heat or hazardous products. Such materials include the following:

a) Reactive metals, such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium;
b) Metal alkoxides, such as sodium methoxide;
c) Metal amides, such as sodium amide;
d) Carbides, such as calcium carbide;
e) Halides, such as benzoyl chloride and aluminium chloride;
f) Hydrides, such as lithium aluminum hydride;
g) Oxyhalides, such as phosphorus oxybromide;
h) Silanes, such as trichloromethysilane;
j) Sulphides, such as phosphorus pentasulphide; and
k) Cyanates, such as methylisocyanate. Water mist systems shall not be used for direct application to liquefied gases at cryogenic temperatures (such as liquefied natural gas) which boil violently when heated by water.

5.7 Environmental Factors

When selecting a system to protect a risk, the effects of water run-off on the environment shall be considered.

5.8 Approval and Testing

Any water mist system that has been tested and approved by a recognized test and approval body shall be deemed to satisfy the requirements of this standard.

NOTE — Any other technology that can provide an equivalent or better level of safety shall not be qualified or deemed as water mist systems, as per this standard.

6 SAFETY REQUIREMENTS

6.1 Hazards to Personnel (General)

6.1.1 For fire situations, suitable safeguards shall be provided to ensure prompt evacuation of and to prevent entry into hazardous atmospheres and also to provide means for prompt rescue of any trapped personnel.

6.1.2 Safety items, such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus, evacuation plans and fire drills shall be considered.

6.2 Hazards to Personnel (Specific to Water Mist)

6.2.1 Normally, discharge of water mist in an occupied area is not likely to pose any serious hazard to the personnel. However, attention is drawn to the following clauses in respect of safety to the personnel during discharge.

6.2.2 Even though one of the fire fighting mechanisms of water mist is displacing oxygen by water vapour, this is a local phenomenon at and close to the flames, that is, where temperatures are high. The major cause of significant oxygen depletion in an enclosure is the fire itself that consumes oxygen and generates combustion gases into the space. The other effects of fire, that is, heat and toxic gases are acutely far more dangerous than any effects related to oxygen depletion with plain water mist as the fire fighting agent.

6.2.3 Direct impingement of water mist could pose an eye hazard. Noise during the operation of water mist systems could pose a hearing hazard. Water mist may also reduce visibility in the surroundings and hence increase the time and difficulty in egress from an affected enclosure.

6.2.4 Injecting water into the enclosure during a large fire situation may have an instantaneous effect of cooling that decreases the volume of buoyant gases followed by hot steam expansion. The end result could be a probable sudden drop in the pressure inside the enclosure, depending on the size of the protected enclosure.

6.2.5 The potential growth of bacteria in stored water supplies may be a concern where water mist systems are utilized in public spaces. If the risk is considered as a potential risk, measures to prevent such growth should be taken and stored water supplies should be tested for bacteria at appropriate maintenance intervals.

6.2.6 Systems using an inert gas as a form of propellant for the water mist shall conform to the safety requirements specified in IS 15493. Systems discharging gas into the protected volume, different from air, shall comply with the requirements of the respective standards.

6.2.7 Water mist systems using additives shall not be used in normally occupied areas unless they have been evaluated to be safe for human exposure at the maximum concentration of the additive that can be reached upon system discharge. Evaluation shall include at least skin irritation, eye irritation, inhalation toxicity and toxicity on human beings.

6.2.8 There are eminent dangers in respect of protection to certain specific occupancies like deep fat dryers where there is a possibility of hot oil splash during discharge of water mist system. Installation manuals shall specify all the precautions to be taken and safety provisions for such occupancies.

6.3 Hazards to Property

6.3.1 Due to the small amount of water that too very finely distributed, water mist is unlikely to cause any serious damage to the equipment in the enclosure as in the case of other water based systems like hydrant, sprinkler, spray or foam systems.

6.3.2 Usage of pure potable water flowing through stainless steel pipes are not likely to cause serious damage to the property and further evaporation of water mist helps in the reduction of water damage to the property below.

6.3.3 Flooding is a possibility but is minimal as water spray system uses very small volume of water and thus quick cleaning is enabled.

6.4 Electrical Hazards

6.4.1 The clearance is the air distance between water mist system equipment including piping and nozzles, and un-enclosed or un-insulated live electrical components at other than ground potential. The minimum clearances provided are for the purpose of electrical clearance under normal conditions; and are not intended for use as safe distances during water mist system operation.

6.4.2 All system components shall be located to minimum clearances from un-enclosed and un-insulated energized electrical components in accordance with the provisions contained in SP 30.

6.4.3 In risk that contain live electrical equipment and where the presence of free water or water mist may create conditions hazardous to personnel, consideration should be given to the evacuation of the area or the shutting down of electrical equipment prior to the discharge of water mist.

6.4.4 Clearance from water mist equipment to the live and un-insulated electrical equipment shall be governed by the relevant provisions of SP 30.

6.4.5 Water mist systems should not be installed in the presence of high voltage live electrical equipment, except where a risk assessment and testing has been carried out and has determined that it is safe to do so.

NOTE — It is preferable that electrical equipment be de-energized prior to discharge of the water mist.

6.5 Other Requirements

6.5.1 Generally, in areas protected by a water mist system, which are capable of being occupied, the following safety requirements shall be provided:

a) Lighting and adequate direction signs for safe evacuation;

b) Pre-discharge, visible and audible alarms; and

c) Warning and instruction signages.

6.5.2 *Water Quality (Water Mist Specific)*

a) Water mist system with additives protecting normally occupied areas shall incorporate a manual lock-off valve unless the additive in the concentration used has been evaluated as safe for human exposure by an appropriate authority. The valve, where fitted, shall be locked whenever the protected area is occupied.

b) Water mist systems using potable water or natural sea water are not considered to present a toxicological or physical hazard and are safe for use in occupied areas.

c) Water supply for a water mist system shall be taken from a source that is equivalent in quality to a potable source with respect to particulate and dissolved solids or from a source of natural sea water.

d) A filter or a strainer shall be provided at each water supply connection or system riser.

e) The maximum filter rating or strainer mesh opening shall be 80 percent of the minimum nozzle waterway dimension.

f) When selecting water mist system for protection of a hazard location, the effects of water run-off on the environment shall be taken into consideration.

7 APPROACH TO DESIGN OF WATER MIST SYSTEM

7.1 System Design

7.1.1 *General*

a) A system shall be designed and installed in accordance with its application for the specific hazard and/or occupancy as defined in their listing or in the relevant fire test reports and performance objectives. Compliance with the above shall address compartment geometry, fire hazard and system variables.

b) The characteristics of the specific application (compartment variables and hazard classification) shall be consistent with the listing of the system.

c) Pre-engineered water mist systems for compartment enclosures shall not be extrapolated beyond the volume, ceiling height, ventilation rate, and number of nozzles tested, unless dimensions of the enclosure are such that additional nozzles are required to maintain nozzle spacing.

7.1.2 *Hazard Analysis*

A fire hazard analysis shall be conducted to determine both the design of the system and the type of detection and activation methods required. The system shall be assessed on the hazard type, fire loading and anticipated fire growth. The case of ignition or re-ignition of the fuel, the fire growth rate and the ability to achieve extinguishment shall be considered when selecting or designing a system.

No general design method is available for water mist protection systems. Performance objectives need to be proven by fire test in the configuration and for the hazard and types of fire scenarios expected.

Recognized third party laboratory testing for water mist systems involve the completion of a series of fire tests identified in a fire test protocol as well as reliability testing of the components that make up the water mist system. The test protocol describes the fire tests needed to prove the water mist system is effective. The fire test specifies the type of fuel in configuration(s) that would be more realistic for the hazard protected. Reliability testing consists of testing all components of the system to verify they will function properly.

7.1.3 *Applicability*

a) Fire test protocols shall be designed to replicate the range of the application parameters associated with a particular hazard or occupancy.

b) The system hardware shall be listed for the intended application.

c) Test protocols shall be conducted to verify the working limits, and installation parameters of the system and its components as described in the manufacturer's design and installation manual.

7.1.4 *Fire Hazard Classification*

a) The fire hazard shall be classified by both the combustible loading and fuel type. The combustible loading shall be evaluated in terms of amount and anticipated fire growth rate.

    1) *Combustible loading* — A fire hazard analysis shall be conducted to determine both the performance level of the water mist system and the protection needs of the hazard. The fire hazard shall be based on the fuel type, quantity of the fuel present (combustible loading) and anticipated fire growth rate.

    2) *Fuel type* — Overall fire hazard is directly related to the type and quantity of the fuel present in a space. The ease of ignition/re-ignition of the fuel, the fire growth rate and the difficulty of achieving control, suppression, extinguishment or any combination thereof, shall be considered when selecting or designing a water mist system.

b) *Class A Fires*

Fuel loading and configuration shall be considered when selecting/designing a system to protect a space or area containing class A materials. Consideration shall be given to the potential for deep seated fires as well as to the potential for smoldering fires.

c) *Class B Fires*

The hazard associated with Class B fires is related primarily to the fuel loading, fuel configuration, flash point and burning rate of the fuel. Pre-burn time also affects the overall characteristics of the fire. Class B fires are grouped into two categories namely, two-dimensional pool fires and three-dimensional spray and running fuel fires. The parameters associated with each category are as follows:

1) *Two-dimensional fires* — Fuel loading and configuration, fuel flashpoint, and pre-burn time pool/spill size.
2) *Three-dimensional fires* — Fuel loading and configuration, fuel flashpoint, pre-burn time; cascade/running fuel fires, fuel flow rate, fire configuration; spray fires, fuel line pressure, fuel spray angle, fuel spray orientation and re-ignition.

d) Class C fires electrical conductivity of water and water mist shall be addressed when considering applications where the primary fire is a Class C fire.

7.1.5 *Combination of Fires*

Combination in fuel loadings and hazards shall be addressed.

7.1.6 The location of fuel in the space shall be considered when selecting and designing a water mist system including the following:

a) Fuel located at higher elevations in the space,
b) Fuel located in close proximity to vent openings,
c) Fuel located in the corners of the space, and
d) Fuel stacked against walls.

7.2 Protected Hazard Features

Water mist systems are intended for the protection of areas in buildings, based on the characterization of the occupancy fire hazard, or for the protection of compartments or specific objects that are characterized by the compartment features and/or object fire hazards.

7.2.1 *Area Classification*

Systems to be designed for area protection shall be characterized by the classification of the occupancy that is most likely performed in the area.

7.2.2 *Compartment Variable*

Compartment characteristics shall include at least the compartment geometry, the openings, if any, the ventilation (natural/ forced). Special consideration shall be given to the degree of obstruction and the potential shielding of the fire location that can be encountered. Floor area, enclosure volume, ceiling height, ventilation conditions and the like shall be considered when designing a system in regard to nozzle location, system flow rate and the total water usage of the system.

7.2.3 *Fire Hazard Variable*

The fire hazard for the compartment/object protection shall be classified according to the combustible loading and the fuel type. The combustible loading shall be evaluated in terms of amount and anticipated fire growth rate.

7.2.4 *Compartment Features*

Systems to be designed for compartment/object protection shall be characterized by compartment/object variables as well as fire hazard variables.

7.3 Ventilation

Ventilation considerations shall include both natural and forced ventilation parameters.

7.3.1 *Natural Ventilation*

The number, size and location of the openings in the space (for example, the door and window) shall be addressed in the design and installation of the system. In some cases, special precautions are necessary to minimize the effects of these openings. These precautions include, but are not limited to, automatic door closures and water mist curtains.

7.3.2 *Forced Ventilation*

The effect of the air handling system in the protected area shall be considered in the design and installation. The system shall shut down prior to system activation, however, if it can be demonstrated that the air-handling system is not detrimental to the performance of the water mist system or has been compensated for, it may continue to operate.

NOTE — Natural ventilation or openings in the enclosure allow the hot gases to exhaust mist from the enclosure, decreasing the system's extinguishing potential in total area protection. The flow of gases in or out of the enclosure, or when air handling equipment is left running, can affect the mixing characteristics of the system and may require additional water mist nozzles to compensate for such conditions. Prior to or simultaneously with the discharge of the system, provision should be made for the closing of doors and dampers, and the shutdown of electrical equipment.

7.4 Design Guidelines for Water Mist Sprinkler Systems (Automatic/Wet Pipe Systems

7.4.1 It is the designer responsibility to match the area/compartment/object fire hazard characteristics and the listing of the successfully passed fire tests of the proposed water mist system (*see* **7.2**).

7.4.2 *Extent of Protection*

Generally, water mist sprinkler protection shall be considered for the entire area within building(s) or plant(s), but need not be provided in the following areas:

a) Stairs, spaces below stair headings (other than rooms above a stair) and lift well.

b) Washrooms, toilets and water closets (but not cloakrooms).

c) Bathrooms fitted with doors having a floor area of less than 5.1 m^2.

d) Cupboards and pantries fitted with doors having a floor area of less than 2 m^2.

e) Rooms or compartments containing electric power distribution apparatus, such as switchgear and dry type transformers, and used for no other purpose(s).

7.4.2.1 A building or storey segregated from the water mist protected building by fire walls of not less than 240 min fire resistance in which each opening is protected by two doors (arranged in series) or fire shutters each of not less than 120 min fire resistance.

7.4.3 Account shall be taken of possible interaction between water mist sprinkler systems and other fire protection measures. Examples of possible adverse interactions between water mist sprinkler protection and other fire protection measures are:

a) Water damage to an inadequately shielded fire alarm control panel in a water mist sprinkler protected area with consequent possible failure of the fire alarm system.

b) Operation or failure of smoke detectors in zones adjacent to one in which water discharge has taken place because of the water spray mist travelling to adjacent zones.

Such possible interactions need careful considerations.

7.4.4 Water mist systems shall meet the following criteria.

7.4.4.1 *Overall criteria*

Nozzles shall be positioned and oriented in accordance with the manufacturer's design and installation manual, and shall meet the established design parameters, such as:

a) Specific hazards and protection objectives minimum and maximum heights;

b) Nozzle type and unique identification;

c) Number of operating nozzles;

d) Minimum and maximum distances between nozzles;

e) Minimum and maximum distances from nozzles to walls;

f) Maximum coverage area per nozzle;

g) Minimum flow rate characteristics for each nozzle;

h) Maximum distance between nozzle and diffusers;

j) Location of nozzles with regard to obstructions;

k) Positioning of nozzles with regard to ceiling (flat, pitched or curved);

m) Minimum and maximum operating nozzle pressures;

n) Nozzle protection;

p) Nozzle ceiling plates used with flush, recessed or concealed water mist nozzles;

q) Minimum and maximum water flow rates and water pressures at the nozzles;

r) Design pressure [pumped systems (pressure *versus* time curve), self-contained systems;

s) Additive requirements, where applicable, allowable range of nozzle orientation angle from vertically down;

t) Classification of automatic nozzle thermal response characteristics as fast, special or standard response; and

u) Maximum compartment volume, if applicable.

7.4.4.2 These design parameters can be used in the successful fire tests for the type of hazard under design consideration.

a) Due to the large variety of different types of water mist systems and hazard applications, some parameters mainly related to the pressure and flow rate cannot be provided in a prescriptive manner by single numbers. In such cases, sufficient and relevant design information shall be provided to enable the reproduction of the system as tested.

b) *Minimum discharge pressure* — The minimum discharge pressure, for water (and atomizing media, where applicable) shall be complied with at all discharge devices in the operating area, including the hydraulically most remote ones, for the entire duration of the system. Where different hazard classifications are protected by the same system, the minimum pressure per each different discharge device shall be met.

c) *Operating area* — The minimum number of nozzles to be considered simultaneously discharging over the operating area shall be indicated in the listing of the system for the specified hazard classification based on actual performance tests.

d) Single area protected by water mist systems shall not exceed 10 000 m^2 or in other words, area served by a single control valve shall not exceed 10 000 m^2.

7.5 Water Mist Nozzles

7.5.1 *Automatic Nozzles*

All nozzles shall be made from corrosion resistant material. Consideration shall be given to the effects of corrosive atmospheres, vibration and intended use when materials are chosen. Where a coating is used, it shall be applied by the nozzle manufacturer and the coated nozzle shall be approved.

Nozzles with glass bulb type heat responsive elements shall be equipped with protective covers that are designed to remain in place during installation and be removed before the spray nozzle system is placed in service.

Nozzles shall be selected, spaced and installed in accordance with the manufacturer's design and installation manual based on successful fire tests taking also into account the following additional parameters:

a) Distance from walls and other obstructions, installation of nozzles to compensate for obstructions and installation around openings; and
b) Minimum allowed distance from fire load distance below ceilings.

Obstruction to discharge pattern of water mist nozzles shall be minimized when defining the interaction between water mist sprinkler nozzles and obstructions located below the nozzles,

The sensitivity and discharge pattern of the water mist nozzles shall not be adversely affected by obstructions, such as beams, light fittings, other nozzles, etc.

The general rule of limiting the size of the obstruction to one third of the distance from the nozzle shall be followed where different indications are not given.

Where external clogging is likely, discharge nozzles shall be provided with frangible discs, blow-off caps or other suitable devices. These devices shall provide an unobstructed opening upon system operation and shall be arranged so that they cannot injure personnel

A nozzle shall be provided with a strainer or filter constructed from corrosion resistant materials. The maximum dimension of an opening in the strainer or filter shall not exceed 80 percent of the smallest orifice diameter being protected.

Spare nozzles may be stocked based on the quality of nozzles used. The stock of spare, individual and thermally activated nozzles shall include all types and ratings installed for the following criteria:

1)	For systems having less than 50 nozzles	: 3 (min)
2)	For systems having 50 to 300 nozzles	: 10 (min)
3)	For systems having 301 to 1 000 nozzles	: 15 (min)
4)	For systems having over 1 000 nozzles	: 30 (min)

Automatic nozzles shall be equipped with a heat sensitive device designed to react at a pre-determined nominal release temperature and colour coded as indicated below.

The temperature rating of the water mist nozzles shall be closest to (at least 30°C greater than) the highest anticipated ambient temperature of the location and within a range of 79°C to 100°C when installed under glazed roofs.

Nozzles shall be permanently marked to identify the manufacturer, model number, year of manufacturing, the approval mark(s), if any, and/or component identification. Nozzles subjected to mechanical damage shall be protected with guards. Guards shall not significantly reduce the effectiveness of the nozzle.

Automatic nozzles shall be equipped with a blow-off cap or other protective device, if the environment is prone to allow clogging of the exit port(s) by foreign material. These devices shall provide an unobstructed opening upon system operation and shall be arranged in such a way as to prevent injury of the personnel.

Water mist nozzles shall have quick response thermal sensitivity rating. Also any water mist nozzle removed from the installation shall be discarded and only new nozzles shall be used.

Escutcheons used in a recessed or flush type nozzle installation shall be a part of a listed nozzle assembly. Cover plates used with concealed nozzles shall also be a part of listed assembly.

In case of an occupancy change involving temperature change, nozzles shall be changed accordingly.

Standard temperature ratings, classifications and colour coding of automatic nozzles shall be as per Table 1.

7.5.2 *Open Nozzles*

All nozzles shall be made from corrosion resistant materials. Consideration shall be given to the effects of corrosive atmospheres, vibration and intended use when materials are chosen. Where a coating is used, it shall be applied by the nozzle manufacturer and the coated nozzle shall be approved.

Open nozzles shall be equipped with a blow-off cap or other protective device, if the environment is prone to allow clogging of the exit port(s) by foreign material. These devices shall provide an unobstructed opening upon system operation and shall be arranged in such a way as to prevent injury of the personnel.

Spare water mist nozzles shall be available in accordance with **7.5.1**.

Nozzles shall be selected, spaced, and installed in accordance with the manufacturer's design and installation manual based on successful fire tests taking also into account its distance from walls and other obstructions installation of nozzles to compensate for obstructions, installation around openings, minimum

Table 1 Temperature Range and Colour Coding of Automatic Nozzles

(*Clause* 7.5.1)

Sl No.	Maximum Ambient Temperature °C	Nozzle Temperature °C	Temperature Class	Nozzle Colour
(1)	(2)	(3)	(4)	(5)
i)	38	57-77	Ordinary	57 Orange 68 Red
ii)	66	79-107	Intermediate	79 Yellow 93 Green
iii)	107	121-149	High	Blue
iv)	149	163-191	Extra high	Purple
v)	191	204-246	Very extra high	Black
vi)	246	260-302	Ultra high	Black
vii)	329	343	Ultra high	Black

allowed distance from fire load, uninterrupted spray pattern, etc.

Nozzles shall be provided with a strainer or filter constructed from corrosion resistant material. The maximum dimension of an opening in the strainer or filter shall not exceed 80 percent of the smallest orifice diameter being protected.

7.6 Design Guidelines for Deluge Systems

7.6.1 Water mist deluge systems are intended for the protection of fire hazards in compartments.

7.6.2 *Types of Compartment Protection Systems*

According to the application characteristics the deluge water mist systems are classified further as:

a) Local application systems,
b) Volume protection systems, and
c) Zoned protection systems.

Compartment protection water mist systems can be either manually or automatically activated as agreed to between the user and the authority.

Local application systems shall be tested for the associated hazard class selected and for the main protection objective/objectives of the applications concerned. Local application systems in multiple hazard areas, where protection for individual objects is foreseen, shall be suitable for all associated hazards present in the area.

Volume protection systems shall be tested for all hazards expected to be present in the volume. Volume protection systems to be installed in a multiple hazard application shall be tested and approved for all hazards present in the volume. Where the spread of fire is likely to involve two or more enclosed volumetric spaces, adjacent fire hazards shall be taken into account and the water mist system shall be designed for the combined hazard.

Zoned systems shall be tested for all hazards expected to be present in each zone but designed for the zone having largest volume. Zoned systems designed for more than one zone shall be tested and approved for all present hazards in the zones. Where the spread of fire is likely to involve two or more zones, adjacent fire hazards shall be taken into account and the water mist system shall be designed for the combined hazards.

7.6.3 Nozzles shall be selected, spaced and installed in accordance with the requirements defined in **7.5** and with the manufacturer’s design and installation manual based on successful fire tests taking also into account the following additional parameters:

a) Type of hazard,
b) Distance to the protected object, and
c) Nozzle orientation.

7.6.4 *Air Velocity, Openings and Ventilation*

7.6.4.1 Air velocity, openings and ventilation shall be taken into account in accordance with the manufacturer’s instructions based on test results.

7.6.4.2 Wherever possible, the ventilation system shall be shut down before the system operates. In those cases where this is not possible or desirable, the air velocity and/or total leakage area shall be within the limits specified by the manufacturer on the basis of tests.

7.6.5 *Automatic Shut-down*

7.6.5.1 During a fire incident, provision shall be made to stop any supply of combustible substances as part of the shutdown emergency procedures (product and raw materials feed) with the exception of the minimum supply for emergency running systems. This point shall also be taken into consideration when specifying the operating period.

7.6.5.2 Normally, power supplies to the equipment in the affected area shall be switched off upon activation of the system or detection of a fire. Minimum supplies for emergency running systems are an exception. Whereas this is not possible for process reasons, provisions shall be taken in the design of system.

7.6.6 *Activation and Control Mechanism for Deluge Systems*

7.6.6.1 *General*

Control and actuation systems shall be electrical, pneumatic, mechanical, or any combination of these. Such systems shall be either manual only or automatic with manual over-ride in accordance with IS 15493.

7.6.6.2 Operating devices, such as pumps, storage container, discharge valves, isolation and discharge controls and ancillaries shall incorporate manual reset facilities. Operation of any container release device shall cause operation of all containers required for that particular risk. All devices shall be located, installed and suitably protected so that they are not subject to mechanical, chemical or other damage which may impede their correct operation.

7.6.6.3 Control and indicating equipment automatic water mist deluge systems, shall comply with IS 2189. A system is solely designed for manual operation, the control and indicating equipment shall comply with the system listing.

7.6.6.4 Audible alarms and visible warning devices shall be provided as follows:

a) *Fire alarm* — In systems that require more than one detector to operate before the extinguishing agent is discharged, a visible indication appropriate to the risk shall light and the alert tone shall sound immediately upon receipt of any alarm.

b) *Do not enter and evacuate* — Where it is required that the protected area be evacuated before system discharge, the initiation of the discharge sequence shall cause these visual devices to illuminate and activate the audible 'evacuate' tone continue after extinguishant discharge until the risk is made safe.

c) *System inoperative* — Any condition that inhibits the automatic discharge of the system shall cause this visual indicator to illuminate. Some of such conditions are:

    1) Operation of maintenance isolation switch;
    2) Fault in actuation system;
    3) Operation of lock-off valve (where fitted);
    4) Operation of manual inhibit switch (where fitted); and
    5) Isolation or fault on any part of the fire detection system.

Automatic mechanical release systems shall employ suitable means such as cables and, where required, drop weights. The control cables shall be run within protective tubes with free turning corner pulleys at all changes of direction. Mechanical control shall be capable of being tested periodically for proper operation. Where fusible links are used, they shall conform to relevant standards.

Manual mechanical release shall be protected from accidental operation. The release shall require a push or pull of not more than 110 N and a movement of not more than 150 mm to ensure operation.

Pneumatic release systems may be operated pneumatically by gas pressure from a stored or continuous source. Alternatively, release systems may be operated directly from gas-pressure-generating heat detection systems. All pneumatic systems shall be capable of being tested periodically for proper operation.

In the case of systems using stored pressure water containers, gas pressure from the storage containers may be used as a source of energy for system release. Alternatively, pressure from separate pilot gas containers may be used.

Where gas pressure from pilot containers is used for the release of multiple water containers, the pilot gas quantity and flow rate shall be adequate to release simultaneously all of the containers for that risk. Pilot gas containers that are not fitted with a pressure indicating device shall be duplicated. The pilot gas shall be used solely for actuating the system.

7.7 Water and Atomizing Gas Supply Design

7.7.1 Water mist systems shall have at least one automatic supply of water and atomizing media, where required, to operate the system at the correct pressure, flow and duration.

7.7.2 Water flow (and atomizing media where required) shall be such to supply the system at the maximum required flow.

7.7.3 The flow required for water mist sprinkler systems shall be based on the nominal flow rate of the hydraulically most favourable nozzles in the operating area, or on the number of nozzles specified to operate simultaneously, whichever is higher. The amount of atomizing gas, where required, shall be sufficient for the above mentioned total flow.

7.7.4 The flow required for deluge water mist systems shall be based on the supply of the largest single hazard or group of hazards to be protected simultaneously. The amount of atomizing gas, where required, shall be sufficient for the above mentioned total flow.

7.7.5 The maximum and minimum pressure of the water supply and atomizing gas, where required, shall be within the approved limits of operating pressure for the nozzles specified by the manufacturer taking into account both the hydrostatic pressure difference and the pipe hydraulic pressure loss.

7.8 Water and Propellant/Atomizing Gas Supply Design

7.8.1 Water mist systems shall have at least one automatic supply of water and propellant/atomizing media, where required, to operate the system at the correct pressure, flow and duration.

7.8.2 Water and propellant/atomizing media, where required, shall be such to supply the system at the maximum required flow.

7.8.3 The flow required for the water mist sprinkler systems shall be based on the nominal flow rate of the hydraulically most favourable nozzles in the operating area, or on the number of nozzles specified to operate simultaneously, whichever is higher. The amount of atomizing gas, where required, shall be sufficient for the above mentioned total flow.

7.8.4 The flow required for the deluge water mist systems shall be based on the largest single hazard or group of hazards to be protected simultaneously. The amount of atomizing gas, where required, shall be sufficient for the above mentioned total flow.

7.8.5 The maximum and minimum pressure of the water supply and atomizing gas, where required, shall be within the approved limits of operating pressure for the nozzles specified by the manufacturer taking into account both the hydrostatic pressure difference and the pipe hydraulic pressure loss.

7.9 Hydraulic Calculations

7.9.1 Design of water mist systems shall be validated by hydraulic calculations. System flow calculations procedures shall be in accordance with:

a) Darcy-Weisbach method for systems designed for intermediate and high pressures, single fluid and single liquid phase systems;

b) Hazen-Williams method for low pressure systems; and

c) Other approved procedures for propellant gas or atomizing media.

NOTE — The procedures and protocols for the calculations shall be as per software recognized and certified by approved national/international agencies.

7.9.2 For single and twin fluid systems, hydraulic calculations shall be based on flow rate and pressure (as specified by the manufacturer and as determined during the tests) on a wetting over 140 m^2 most remote area or simultaneous operation of 9 water mist sprinklers, whichever is greater. For water mist deluge systems, hydraulic calculations shall be based on flow rate and pressure (as specified by the manufacturer and as determined during the tests).

7.9.3 For dry and pre-action systems, water delivery delay associated with the water transit time from the water supply valve to the most remote nozzle shall be calculated and confirmed to be less than the manufacturer’s stated maximum water delivery time. In no case shall the water delivery time exceed 60 s.

7.10 Water Mist Systems Supply

7.10.1 *Mist System with Pumping Arrangements*

Pumped systems are systems with a continuous supply with a specified minimum duration and pressure, for example, systems connected to a public water main, systems supplied by a water reservoir with one or more pumps, which may be electric, diesel or pneumatically driven, etc, with or without an atomizing/propelling agent supply. A pumped system can be supplied by a public or private water main either directly or supplemented by a water main booster pump set.

7.10.2 *Mist Systems (Self-Contained)*

Systems supplied by a limited amount of water and/or atomizing/propelling media contained in specific containers or cylinders, known as ‘self-contained systems’, characterized by a specified duration of the discharge.

A self-contained system has no connection to an external water source and typically comprises a set of cylinders or a skid mounted pressure tank, connected to a source of gaseous stored pressure (for example, pressurized air or inert gas cylinders) and does not require any external power source to operate.

7.11 Mist System with Pumping Arrangements

7.11.1 Pumps used in water mist systems are usually of centrifugal or positive displacement type although the continuous developing technology of water mist systems may propose different solutions. Centrifugal pumps are used in low pressure and medium pressure systems, whereas positive displacement pumps are used in medium and high pressure systems.

7.11.2 Pump sets supplying water mist systems shall be designed to start both automatically and manually, though they shall be always in ‘auto’ mode.

7.11.3 The rated duty of the pump set shall be a function of the most unfavourable or the most favourable area curve or of the most demanding deluge system. When measured at the supplier’s test facility, the pump set shall provide:

a) A pressure at least 10 percent higher than that required for the most demanding system for centrifugal pump,

b) A flow at least 10 percent higher than that required for the most demanding system for positive displacement pumps, and

c) Pump set shall also be capable of providing the flow and pressure of the most unfavorable situation within the network.

7.11.4 Installation of pumps, type of pumps and prime movers, other components within the pump room like piping, valves, gauges, etc, pump room location and electrification of motorized pumps, etc, shall be governed by various provisions in **7**. These requirements, by and large, remain the same for sprinkler installation as prescribed in **9** of IS 15105.

7.11.5 *Pumps Operation*

Pump shall be automatic in operation that is, when the pressure in the system falls due to operation of water mist nozzle(s), pump shall be triggered by pressure switches or pressure sensing devices or pressure transducers or any other recognised method. The auto starting mechanism shall be evaluated and certified by recognised national/international agencies as a part of approval of the water mist system.

Means shall also be provided to check and test the pump set starting with the type of auto-start arrangement as above without causing disturbance to the pressurized system.

The first pump set shall start automatically when the pressure in the system falls to a value that shall be indicated in the manufacturer design and installation manual or as decided earlier.

Where two pump sets are installed, the second one shall also start automatically as the first one (in case minimum pressure is not reached) and a delay shall be provided so as to avoid simultaneous starting of both units. When more pumps are required, there shall be a sequential start (pre-set pressure gradient) of each pump as above. Once the pump set has started, it shall continue to run until stopped manually.

7.12 Mist Systems (Self-Contained) Arrangements

7.12.1 *Pressurized Storage Arrangements*

7.12.1.1 The arrangement of pressurized storage containers and accessories for either water or gas shall be as follows:

a) Storage containers shall be installed, mounted and braced in accordance with the manufacturer's listing.
b) Containers and accessories shall be located and arranged so that inspection, testing, recharging and other maintenance are facilitated, and interruption to protection is kept to a minimum.
c) Storage containers shall be located as close as possible to the hazard or within the hazards they protect and shall not be exposed to fire or mechanical damage in a manner that affects performance.
d) Containers should be located outside of and as near as practicable to, the risk. Containers protecting a single risk can be located within the protected area they serve only if sited to minimize the risk of exposure to fire and explosion.
e) Storage temperature should not exceed 55°C nor be less than 4°C, unless the system is designed for operation in storage temperatures outside this range. External heating or cooling may be used to keep the temperature within the desired range.
f) Containers shall be so located that they are not subject to severe weather conditions or to mechanical, chemical or other damage. Where excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.
g) Reliable means shall be provided to indicate the pressure in refillable pressurized gas containers.
h) Water cylinders shall have special linings.
j) Water cylinders shall be filled with demineralized water.

7.12.1.2 *Atomization gas for twin fluid systems*

Atomizing gas essential to the generation of water mist shall be taken from a dedicated source and shall comply with the following:

a) Atomizing gas shall be supervised for high and low pressure.
b) Regulators controlling the supply of water and atomizing gas shall be listed for the intended purpose.
c) A check valve or other means shall be installed in the piping at the supply point to every nozzle to prevent the entrance of water into the atomizing gas.
d) Filters or other means to protect nozzles from obstructions shall be provided.
e) Where used, air compressors shall be a dedicated source and shall be listed for use on fire protection systems.
f) Electrically driven compressors used as a dedicated supply shall be connected to the emergency supply.

7.13 Water Supply

7.13.1 The water supply for the system shall preferably use potable water. Where sea water is used, provisions shall be made to allow thorough flushing of the system piping with fresh water after a functioning. Other sources can also be used, provided they are treated from time-to-time to remove all suspended matters and impurities.

7.13.2 All practical steps shall be taken to ensure the availability and reliability of water supplies. A water supply shall not be affected by possible frost conditions, drought, flooding or any other conditions that could reduce the flow or effective capacity or render the supply inoperative including tampering.

7.13.3 In case of a reliable inflow into the tank(s), total capacity required can be reduced by 15 min inflow from the source.

7.13.4 Fill-line for the water shall be routed through <100 µm filter (as a part of the supply) and it is preferable to keep the chloride content within 50 ppm.

7.13.5 Water storage shall be constantly supervised, cleaned and flushed, whenever required. Cleanliness shall be maintained always.

7.13.6 Each pump driven mist system arrangement is configured to provide the total suppressant requirement typically for 60 min of water to the most remote nine water mist nozzles (other than for expellant cylinder band) or 140 m^2 area, whichever is greater. For deluge systems, water shall be available for 60 min based on pressure/flow requirements arrived from hydraulic calculations.

7.13.7 Water mist systems shall be connected to one or more of the following types of water supplies depending upon the size and nature of the occupancy under protection:

a) Pressure tank or vessel;
b) Stored pressure cylinders;
c) Automatic fire pump(s) drawing water from a dedicated water tank(s);
d) Elevated tanks; and
e) Separate break tanks as per manufacturer’s specification and approval limitations.

7.13.8 If water for the mist system is stored in a common tank along with other fire fighting facilities like hydrant or sprinkler systems, capacity of the tank shall be equivalent to sum total of water requirements for all such systems.

7.13.9 If water for the mist system as well as domestic supply is stored in the same tank, the suction puddle for the domestic pumps shall be connected at a height so that, supply for the mist system shall not be exhausted.

7.13.10 Separate and dedicated tank (break tank) can also be provided for the water mist system subject to compliance with **7.13.1** and **7.13.5**. Also permanently connected water fill-in arrangements shall be available for this tank.

7.13.11 Water storage facilities shall otherwise comply with various provisions (as applicable) stated in IS 15105.

8 PUMPSETS

8.1 General Requirements

8.1.1 Exclusive pumpsets shall be used for the water mist systems. They shall be of the approved type out of the following:

a) Electric motor driven centrifugal pumps;
b) Compression ignition engine driven centrifugal pumps; and
c) Positive displacement pumps.

In all the above cases, pumps shall be automatic in action.

8.1.2 Pumps used in water mist systems are usually of centrifugal or positive displacement type although the continuous developing technology of water mist systems may propose different solutions. Centrifugal pumps are used in low pressure and medium pressure systems, whereas positive displacement pumps are used in medium and high pressure systems.

8.1.3 Parts of pumps like impeller, shaft sleeve, wearing ring, etc, shall be of non-corrosive metal, preferably brass or bronze.

8.1.4 Where sea water is used, or where the quality of water necessitates use of special metals and alloys, the use of such metals and alloys shall be insisted upon.

8.1.5 The capacity of pump(s) shall depend on the type of hazard protected and flow requirements as per calculations of water demand for given system. Electrical or diesel-driven pumps supplying water mist systems shall be of sufficient capacity to exceed both the system flow rate and pressure demands as determined by hydraulic calculations by a minimum of 10 percent for both flow and pressure for centrifugal pumps, and 10 percent for flow in case of positive displacement pumps (*see* **7.11.3**).

8.1.6 Where water mist systems are provided for several buildings from a central pump house through a common delivery manifold, one additional pump of similar capacity shall be provided as a standby in case the number of main pumps is less than three. Where separate systems are provided for each building also, one standby pump of similar capacity shall be provided for each system in addition to the main pump(s) in case the number of main pumps is less than three.

NOTE — Emergency power shall be mandatory for the pumps from two different sources like captive generation plant or dedicated diesel generator supply, capable of running the aggregate installed pumping capacity.

8.1.7 Make-up pumps of adequate capacity shall be provided for pre-filling of the entire pipeline system.

8.1.8 Each pump shall be provided with a pressure gauge on the delivery side between the pump and the non-return valve, and a plate giving the delivery head, capacity and the number of revolutions per minute. Also separate pressure gauge shall be provided on common manifold.

8.1.9 Each pump shall be provided with independent suction pipe flooded suction and further provided with sluice or cut off valves. The Net Positive Suction Head (NPSH) available at site exceeds the required NPSH by at least 1 m at 110 percent of the duty point as applicable in terms of the manufacturer's curves and approval limitations, if any.

8.1.10 Suction piping shall be laid either horizontal or with a continuous slight rise towards the pump to avoid the possibility of air locks forming in the pipe. No butterfly valves are allowable in suction pipelines.

8.1.11 Pumps shall not be installed in the open. The pump room shall be so located as to be both easily accessible and where any falling masonry and the like from other buildings occasioned by fire and other causes, cannot damage the pump room. Normally, pump rooms shall be located 6 m away from all surrounding buildings and overhead structures. Where this is not feasible, they may be attached to a building provided a fire wall having a rating of at least 120 min is constructed between the pump room and the attached building, the roof of the pump room is of RCC construction at least 100 mm thick and access to the pump room is from the outside. The pump rooms shall normally have brick/ concrete walls and non-combustible roof with adequate lighting, ventilation and drainage arrangements.

NOTE — The pump room shall be located 30 m clear of the equipment/vessels handling or storing flammable liquids/ solvents and/or gases.

8.1.12 In case of twin fluid systems, quantity of gas required to drive the pump shall be sufficient to drive the pump for duration as specified in the manufacturer's installation and design manual.

8.2 Electrically Driven Pumps

8.2.1 The sub-stations and/or DG houses supplying power to the fire pumps shall be of incombustible construction and shall be located at least 6 m away from all surrounding buildings. Where this is not feasible, all door and window openings of the surrounding buildings within 6 m of the sub-stations and/or DG houses shall be protected by single fire door and 6 mm thick wired glass in steel framework, respectively. Likewise, roof eaves, if any of the surrounding buildings falling within 6 m of the sub-station(s) and/or DG houses shall be cut and wall raised as a parapet. The above provision shall also apply when the sub-station(s) and/or DG houses are within 6 m of each other.

8.2.2 Where the sub-stations and/or DG houses are attached to buildings, a fire wall having a rating of at least 120 min shall be constructed to segregate the sub-station(s) and/or DG house(s) from the attached buildings; and where the attached building is storeyed, the roof of the sub-station(s) and/or DG houses shall be of RCC construction of at least 100 mm thickness.

8.2.3 Transformer cubicles inside these sub-stations shall be separated from HT/LT cubicles and from each other by blank brick/stone/concrete walls of 355 mm thickness or of RCC of 200 mm with door openings, if any, therein being protected by single fire door with fire rating of at least 120 min. The sub-stations and DG houses shall also be separated from each other as above.

8.2.4 Transformers installed outdoors, which are supplying power to fire pump(s), shall also be located at least 6 m away from all the surrounding buildings (including substations and/or DG houses). Where this is not feasible, all door and window openings of the surrounding buildings (including sub-stations and/or DG houses) within 6 m of the of the transformers shall be protected by single fire doors and 6 mm thick wired glass in steel framework, respectively. Likewise, roof eaves, if any of the surrounding buildings falling within 6 m of the transformers shall be cut and wall raised as a parapet. Blast walls of bricks/stone/concrete blocks of 355 mm thickness or of RCC of 200 mm thickness shall be constructed between two transformers and these walls shall be extended horizontally by 600 mm beyond the extremities of the transformers and vertically 600 mm above the highest point of the transformers.

NOTE — High hazard (B) occupancies, sub-stations supplying power to fire pumps shall, in addition to complying with the above provisions, be located 30 m clear of all equipment where flammable fluids having a flash point below 65°C are handled and/or stored.

8.2.5 Overhead feeders to sub-stations supplying power to the fire pumps are not permitted within a horizontal distance of 15 m of any process building/plant or tanks containing flammable liquids 6 m of any other building or tanks containing non-flammable liquids or of storage in open.

8.2.6 In case the feed to such sub-stations is by means of underground cables, the cables shall not pass under any building or permanent structure.

8.2.7 Sufficient spare power shall always be available to drive pumping set(s) at all times throughout the year.

8.2.8 The electric supply to the pumping set(s) shall be entirely independent of all other equipment in the premises, that is, even when the power throughout the entire premises is switched off, the supply to the pump shall continue to be available uninterrupted. This can be achieved by taking the connection for the pump(s) from the incoming side of the main LT breaker. However, in cases where two or more transformers and/or sources of supply are connected to a common bus bar or where there is provision of a bus coupler between the bus bar sections, the connection may be taken through the bus bars.

8.2.9 The fire pump circuit shall be protected at the origin by an automatic circuit breaker so set as to permit the motor to be overloaded during an emergency to the maximum limit permissible by the manufacturer. Further, the under voltage release/no volt coil of the circuit breaker shall be removed.

NOTE — Where cable lengths are long enough to warrant backup protection, authorities may insist on provision for such a protection.

8.2.10 It is recommended that telltale lamps which could continuously glow when power is available to the fire pump(s) circuit be provided and fixed in a prominent position, both in the sub-station and in the pump room.

8.2.11 A direct feeder without any tappings shall be laid from the sub-station to the pump house. The feeder shall be laid underground and shall not pass under any building or permanent structure.

8.2.12 Where there is more than one source of power for the operation of pumping set(s), every electrical circuit shall preferably be so designed as to ensure that when necessary the set(s) continue to operate without the manual operation of an emergency switch.

8.2.13 The pumping set(s) shall be securely mounted on a robust bedplate, if of the horizontal type, and shall be free from vibration at all variations of load.

8.2.14 The rating and design of motors and switchgear shall conform to IS/IEC 60947 (Parts 1 to 5). The motor shall be of continuous rating type and its ratings shall be equivalent to the horse power required to drive the pump at 150 percent of its rated discharge in case of centrifugal pumps.

8.2.15 The motor shall be of totally enclosed type or drip-proof type, the latter having their air inlets and outlets protected with meshed wire panels to exclude rodents, reptiles and insects.

8.2.16 The motor(s) shall be wound for class B insulation preferably for class E and the windings shall be vacuum impregnated with heat and moisture resisting varnish, and preferably glass fibre insulated to withstand tropical conditions.

8.2.17 Motors wound for high tension supplies shall have a suitable fixed warming resistance to maintain the motor windings in a dry condition at all times and particularly under monsoon conditions. The resistance shall be connected to the lighting or other equivalent circuit.

8.2.18 Heating apparatus shall also be provided, when necessary, for medium tension motor where they, are located below ground level, in order to maintain the motor windings in a dry condition. Adequate drainage arrangements shall also be provided in the pump house in such cases.

8.2.19 The incoming cable to the fire pump room shall terminate in an isolating switch fuse unit incorporating the HRC fuses and, where, necessary provided with a distribution system.

8.2.20 The starting switchgear for the fire pumps shall be suitable for direct on line or star-delta starting but other alternative arrangements are subject to prior approval of the authorities concerned. It shall also incorporate an ammeter with a clear indication of the motor full load current.

NOTE — Remote controlled starting arrangements are subject to prior approval of the authorities concerned.

8.2.21 Cables for motors and switchgears shall be armoured or enclosed in heavy gauge screwed steel conduit according to conditions.

8.2.22 It is recommended that the equipment throughout be painted fire red (shade No. 536 as per IS 5) and suitably marked for identification.

8.2.23 Necessary spare parts including a set of fuses (in a glass fronted box) shall be kept in readiness at all times in the pump house.

8.2.24 The wiring in all installations shall be done in accordance with SP 30.

8.3 Compression Ignition Engine Driven Pumps

8.3.1 *Pump Room*

The pump room shall be artificially heated, if necessary, to maintain the temperature of the room above 10°C. Adequate ventilation shall be provided for the air required for aspiration and to limit the temperature rise in the room to 10°C above the ambient temperature when the engine is on full load.

8.3.2 *Engine*

The engine shall be,

a) of compression ignition mechanical direct injection type, capable of being started without the use of wicks, cartridges, heater plugs or ether, at an engine room temperature of 7°C and shall accept full load within 15 s from the receipt of the signal to start.

b) naturally aspirated, supercharged or turbocharged and either air or water cooled. In the case of charged air cooling by means of a belt driven fan or of a belt driven auxiliary water pump there shall be multiple belts such that should half the belts break, the remaining belts would be capable of driving the fan or pump.

c) capable of operating continuously on full load at the site elevation for a period of 6 h.

d) provided with an adjustable governor to control the engine speed within 10 percent of its rated speed under any conditions of load up to the full load rating. The governor shall be set to maintain the rated pump speed at maximum pump load.

e) provided with an in-built tachometer to indicate the RPM of the engine.

f) provided with a time totaliser (hour counter).

Any manual device fitted to the engine which could prevent the engine starting shall return automatically to the normal position.

8.3.3 Engines, after correction for altitude and ambient temperature shall have bare engine horsepower rating equivalent to the higher of the following two values:

a) 20 percent in excess of the maximum brake horsepower required to drive the pump at its duty point; or

b) The brake horsepower required to drive the pump at 150 percent of its rated discharge in case of centrifugal pumps.

8.3.4 The coupling between the engine and the pump shall allow each unit to be removed without disturbing the other.

8.3.5 *Cooling System*

The following cooling systems are acceptable:

a) Cooling by water from the discharge of fire pump (taken off prior to the pump discharge valve) direct into the engine cylinder jackets *via* pressure reducing device to limit the applied pressure to a safe value as specified by the engine manufacturer. The outlet connection from this system shall terminate at least 150 mm above the engine water outlet pipe and be directed into an open tun dish so that the discharge water is visible.

b) A heat exchanger, the raw water being supplied from the fire pump discharge (taken off prior to the pump discharge valve) *via* a pressure reducing device, if necessary, to limit the applied pressure to a safe value as specified by the engine manufacturer. The raw water outlet connection shall be so designed that the discharged water can be readily observed. The water in the closed circuits shall not be less than that recommended by the engine manufacturer. If the auxiliary pump is belt driven there shall be multiple belts so that should half the belts break, the remaining belts shall be capable of driving the pump.

c) A frame or engine mounted air cooled radiator with a multiple belts driven fan from the engine. Even when half the belts are broken, the remaining belts shall be capable of driving the fan. The water in the closed circuit shall be circulated by means of the auxiliary pump driven by the engine and the capacity of the closed circuit shall be not less than that recommended by the engine manufacturer.

d) Direct air cooling of the engine by means of multiple belts driven fan. When half the belts are broken, the remaining belts shall be capable of driving the fan.

NOTE — In case of systems described above, a failure actuated audio-visual alarm shall be incorporated.

e) It is also recommended to provide the cooling water supply piping with the following:
    1) Label showing the intended direction of flow;
    2) An indicating manual shut-off valve;
    3) An approved flushing type strainer;
    4) Pressure regulator;
    5) An automatic valve;
    6) Second indicating manual shut-off valve;
    7) Pressure gauge towards the engine after the last manual valve; and
    8) Bypass line with manual valves, flush type strainer and a pressure regulator around the manual shut-off valve, strainer, pressure regulator, and automatic valve.

8.3.6 *Air Filtration*

The air intake shall be fitted with the filter of adequate size to prevent foreign matter entering the engine.

8.3.7 *Exhaust System*

The exhaust shall be fitted with a suitable silencer and the total backpressure shall not exceed the engine maker's recommendation. When the exhaust system rises above the engine, means shall be provided to prevent any condensate flowing into the engine.

8.3.8 *Engine Shutdown Mechanism*

This shall be manually operated and return automatically to the starting position after use.

8.3.9 *Fuel System*

a) *Fuel* — The engine fuel oil shall be of quality and grade specified by engine makers. Sufficient fuel shall be kept on hand at all times to run the engine on full load for 2h in addition to that in the fuel tank.

b) *Fuel tank* — The fuel tank shall be of welded steel construction relevant to Indian or foreign standard for mild steel drums. The tank shall be mounted above the engine fuel pump to provide a gravity feed unless otherwise recommended by the manufacturers. The tank shall be fitted with an indicator showing the level of fuel in the tank. The capacity of the tank shall be sufficient to allow the engine to run on full load for at least 2 h.

NOTE — There is more than one compression ignition engine driven pump set, there shall be separate fuel tank and fuel feed pipe for each engine.

c) *Fuel feed pipes* — Any valve in the fuel feed pipe between the fuel tank and the engine shall be placed adjacent to the tank and it shall be locked in the open position. Pipe joints shall not be soldered and plastic tubing shall not be used.

8.3.10 *Auxiliary Equipment*

The following shall be provided:

a) Sludge and sediment trap,
b) Fuel level gauge,
c) An inspection and cleaning hole,
d) Filter between the fuel tank and fuel pump mounted in an accessible position for cleaning, and
e) Means to enable the entire fuel system to be bled of air.

NOTE — Air relief cocks shall not be used; and screwed plugs may be used.

8.3.11 *Starting Mechanism*

Provision shall be made for two separate methods of engine starting, namely automatic starting by means of a battery powered electric starter motor incorporating the axial displacement type of pinion, having automatic repeat start facilities initiated by a fall in pressure in the water supply pipe to the spray installation. The battery capacity shall be adequate for ten consecutive starts without recharging with a cold engine under full compression. Manual starting by crank handle, if engine size permits or electric starter motor.

NOTE — The starter motor used for automatic starting may also be used for manual starting provided there are separate batteries for manual starting.

8.3.12 *Battery Charging*

The means of charging the batteries shall be by a 2 rate trickle charger with manual selection of boost charge and the batteries shall be charged in position. Where separate batteries are provided for automatic and manual starting the charging equipment shall be capable of trickle charging both the batteries simultaneously. Equipment shall be provided to enable the state of charge of the batteries to be determined. It is recommended to provided stand by batteries for each engine.

8.3.13 *Tools*

A standard kit of tools shall be provided with the engine and kept on hand at all times.

The following spare parts shall be supplied with the engine and kept on hand:

a) Two sets of fuel filters, elements and seals;
b) Two sets of lubricating oil filters, elements and seals;
c) Two sets of belts (wherever used);
d) One complete set of engine joints, gaskets and hoses;
e) Two injector nozzles;
f) One complete set of piston rings for each cylinder; and
g) One inlet valve and one exhaust valve.

8.3.14 *Engine Exercising*

The test shall be for a period of at least 5 min each day. Where closed circuits cooling systems are used, the water level in the primary system shall be checked at the time of carrying out each test and, if necessary, water shall be added during the course of test procedure.

8.3.15 Performance can be ensured when the following conditions are complied with:

a) To test the engine at least once a week;
b) To maintain the temperature of the engine room at not less than 4.5°C at all times;
c) To maintain the minimum quantity of fuel oil required;
d) To use a good grade of fuel oil equivalent in quality to that specified by the engine maker; and
e) To keep on hand the spare parts required as specified above.

8.4 Other Requirements for Pumps

8.4.1 Where there is more than one pump set installed, the suction pipes shall not be interconnected. Where a redundant system is required, the full flow demand of the system shall be met by a main pump set and a reserve pump set having the same capacity.

NOTE — *See also* **7.11.5.**

8.4.2 The following conditions of the electric pump shall be monitored:

a) Power available to the motor and, where a.c. on all three phases;
b) Pump on demand;
c) Pump running;
d) Start failure/common fault; and
e) Manual and auto status.

8.4.3 All monitored conditions shall be visually indicated individually in the pump room. They shall also be visually indicated at a location permanently attended by responsible personnel. Pump running and fault alarms shall also be audibly indicated at the same place.

8.4.4 *Starter Alarm Indication (Engine Driven Pump Set)*

8.4.4.1 The following conditions shall each be indicated both locally and at a responsibly manned location:

a) Use of any switch which prevents the engine starting automatically;
b) Failure of the engine to start after the six attempts;
c) Pump running;
d) Diesel controller; and
e) Manual and automatic status.

8.4.4.2 When commissioning an installation, the automatic starting system of the diesel engine shall be activated with the fuel supply isolated for the 6 cycles each of not less than 15 s cranking and not more than 15 s or less than 10 s rest. After completion of 6 starting cycles, the fail to start alarm shall operate. The fuel supply shall then be restored and the engine shall start when the manual start test button is turned on.

9 COMPONENTS

9.1 Water Mist Nozzles

See **7.5.**

9.2 Pipes and Fittings

9.2.1 Pipe work material for all water and atomizing media shall be of stainless steel to relevant Indian standard or of at least equivalent quality in respect to corrosion. Alternative solutions are acceptable if the same level of safety in respect to clogging of the chosen nozzle and filters due to corrosion can be proven. The pipe work shall be able to withstand at least four times the design pressure.

9.2.2 Piping material shall be stainless steel of suitable grade or of at least equivalent quality in respect to both corrosion and fire resistance. Alternate solutions are acceptable if the same level of performance can be proven with respect to clogging of the chosen nozzle and filters due to corrosion, and if the alternative material can be proven to be equally fire resistant. Zinc coated pipes are not acceptable for the water mist installation piping. The chosen material shall be suitable to withstand the anticipated temperatures at the site of installation.

9.2.3 All system piping and fittings shall be rated for the maximum working pressure to which they are exposed. The pipe work shall be installed in accordance with the manufacturer's design and installation manual, and shall be protected against corrosion. Pipes and fittings shall be installed in such a way that the pipe work is not exposed to damage, for example, by fire, passing vehicles, frost and seismic movement.

9.2.4 Special consideration shall be given to systems installed in corrosive environments and where possible thermal expansion problems which may occur due to very long straight pipe runs.

9.2.5 Installation of piping and fittings shall comply with various provisions of IS 15105. Bending of pipe or tube shall be permitted, provided bends are made without kinks, ripples, distortions, reductions in diameter or any noticeable deviations from a round shape. The minimum radius of a bend shall be in accordance with the manufacturer's specifications. All threads used in system piping shall conform to the requirements of relevant standards. Joint sealing tape, compounds or thread lubricants shall be applied only to the male thread. All fittings on system piping shall be suitable for the maximum subjected pressure. Fittings downstream of the strainer shall be of corrosion resistant material such as copper, stainless steel or hot-dipped galvanized steel where used, flanges shall conform to the requirements of relevant standards.

9.2.6 Welding and brazing shall conform to the requirements of relevant standards and filler materials used in brazing shall have a melting point in excess of 535°C. Welding or brazing fluid residue shall be removed prior to installation.

9.2.7 Each pipe or section of pipe work shall be cleaned after preparation and before assembly. The pipe work shall be free of particulate matter and oil residue before the installation of nozzles or discharge devices. All the system piping and fittings shall be installed in such a way that the entire system can be drained. Where a system employs thread sealing materials such as tape or has welded or brazed joints, dirt traps shall be provided. Dirt traps shall consist of a tee with a capped dirt leg at least 50 mm long.

9.2.8 *Pipe Supports*

Piping shall be securely supported and allowance shall be made for thrust forces, vibration, expansion, contraction and heat resistance. It shall be designed to withstand likely vibration and mechanical, chemical or other damage. Where there is the possibility of explosion, the piping shall be attached to supports that are least likely to be displaced. In all other respects hangers shall comply with the requirements of relevant standards.

The maximum distance between supports shall take into account the total mass of the pipe and contents. The distance between supports shall be in accordance with Table 2.

9.3 Strainers

9.3.1 Line strainers or filters shall have a clean-out port preferably with replacement strainer or filter elements. Filters or strainers without replaceable elements may only be used if they are included as a component of a listed system. Such filters or strainers shall be installed with dismountable joints to facilitate the removal and replacement of the complete unit. The maximum filter or strainer mesh opening shall

Table 2 Spacing for Pipe Supports

(*Clause* 9.2.8)

Sl No.	Nominal Pipe Size mm	Maximum Spacing Between Hangers m (feet)
(1)	(2)	(3)
i)	6-14	1.21 (4.00)
ii)	15-22	1.52 (5.00)
iii)	23-28	1.82 (6.00)
iv)	30-38	2.12 (7.00)
v)	40-49	2.42(8.00)
vi)	50-59	3.00 (10.00)
vii)	60-70	3.33 (11.00)
viii)	71-89	3.64 (12.00)
ix)	90-108	3.94 (15.00)

be 80 percent of the minimum nozzle waterway dimension. Strainers and filters shall be installed and arranged to facilitate inspection, maintenance and replacement.

9.3.2 A filter or a strainer shall be provided at each water supply connection or system riser. Strainers shall be made of corrosion resistant materials. For pressure bearing parts and for the sieve, metallic materials shall be used. The flow direction shall be given on the body of system strainers. It shall be possible to take out the sieve and the dirt particles of system strainers without having to remove the strainer housing.

9.3.3 All parts shall be constructed in such a way that wrong mounting will be obvious. The design pressure shall be equal to the system operating pressure, with a minimum of 12.5 bar. Strainers shall be designed in such a way that spheres with a diameter of more than 0.8 times the minimum nozzle waterway dimension cannot pass the strainer.

9.3.4 Nozzles with waterways (that cannot be passed by a 4 mm sphere) shall be equipped with upstream strainers. These strainers shall be designed to prevent any particles carried in the discharge pipe work from clogging the discharge orifices. The free flow through the range pipe shall not be obstructed by the strainers of nozzles installed directly into a pipe fitting, that is, no part of the strainer shall protrude into that pipe. If the nozzle strainer is projecting from the nozzle inlet into the pipe fitting, the design shall be such that a sphere with a diameter of 3 mm can pass the waterways between the inner surface of the pipe fitting and the outer surface of the strainer

NOTE — The pressure loss of the strainer shall be taken into account during hydraulic calculation.

9.4 Valves

9.4.1 *Control/Activation Valves*

Control and activation valves shall include any device or valve that automatically opens to supply water to the nozzles after the detection of a fire. Control and activation valves shall operate by an approved mechanical, electrical, hydraulic or pneumatic means. For control valves with actuator mechanism, such as pneumatic type, hydraulic type, or electrical type, the specifications of the actuator shall match the valve operation criteria.

Control valves shall be suitable for the pressures, temperatures and environment imposed on them. They shall be in accordance with the acceptance criteria of the essential features of the tests as per their listing. The valve shall be made of corrosion resistant material, or having corrosion resistant finishing. The valve shall have a clear mark to indicate the correct way of installation. Further, the valves shall be installed such that they are not subject to mechanical, chemical or other damage that would render them inoperative.

9.4.2 *Shut-off Valves*

Shut-off valves used in systems shall be used for design pressures upto 12.5 bar and shall meet the requirements of the relevant standards. If shut-off valves are installed for systems operating above 12.5 bar, the shut-off valve shall be suitable for the applicable pressure class, and they shall be listed for such use.

Valves shall include an ‘open–shut’ indicator, which cannot be tampered with. Valves shall be protected against unauthorized tampering.

9.4.3 *Check Valves*

Check valve shall be installed between the system and the point of permanent connection to a potable water supply. They shall be installed in accordance with the manufacturer's listing and relevant Indian standards. Where additives are used in the water mist system, either by injection into flowing lines or by premixing into stored water sources, a backflow preventer shall be installed between the system control valve or stored water supply and a permanent connection to a potable water supply.

Check valves shall be installed in the main feed lines, near the control valves of both the water and pneumatic system piping of a twin fluid system, to prevent the backflow of water or atomizing fluid into the companion piping. Where the water and atomizing fluid are separated by an air gap, check valves shall be permitted to be omitted.

9.4.4 *Safety Valves*

Safety valves or pressure relief valves are to be designed to withstand a pressure equal to 1.5 times the design pressure of the system.

9.4.5 *Pressure Regulating Valves (Water)*

Pressure regulating valves shall be installed in any portion of the system where the potential exists for the system pressure to exceed the maximum rated working pressure of the system or system components or both. These valves shall open when the system pressure reaches 95 percent of the system rated pressure.

A relief valve of not less than 13 mm shall be provided on the discharge side of the pressure regulating valve that is set to operate at a pressure not exceeding the system-rated pressure. A water flow test valve that is sized to produce the designed flow of the pressure reducing valve shall be installed on the downstream side of the pressure reducing valve. A sign indicating the correct discharge pressure for static and residual pressures shall be attached to the pressure reducing valve.

9.4.6 *Pressure Regulating Valves (Gas)*

Pressure regulating valves shall be installed in accordance with the manufacturer's recommendations and shall be installed when the supply pressure is higher than the design operating pressure of the water mist system. Such valves shall be capable of providing a stable regulated output at the rated flow capacity and design setting, over the full range of input pressures that will be experienced over the course of the discharge period.

Downstream pressure creep under no-flow conditions shall not exceed the lesser of the downstream components pressure rating or the pressure relief valve set point, if provided. Pressure set, point adjusting mechanisms on the pressure regulating valves shall be tamper resistant and the adjustment shall be indicated by a permanent marking. A means to indicate evidence of tampering shall be provided. The set point of these valves shall be set by the manufacturer. Permanent markings shall indicate the inlet and outlet connections of the valves.

9.5 Pressure Gauge

9.5.1 Pressure gauges shall be installed in the following locations:

a) On both sides of a pressure regulating valve;
b) On the pressurized side of all supply connections;
c) System control valves;
d) On all pressurized storage containers;
e) On all air supplies for dry pipe and pre-action systems; and
f) When multiple gas cylinders are employed with their individual cylinder valves sealed or supervised in the open position and connected to a pressurized manifold, a single pressure gauge on the pressurized section of the manifold shall be permitted for indicating the pressure in all the gas cylinders.

9.5.2 The required pressure gauges shall be compatible with their intended use and shall have an operating range not less than twice the working pressure of the system.

9.6 Storage Containers

9.6.1 *Gas Cylinder*

Gas cylinders used for the storage and transportation of gas at high pressures shall conform to the requirements of IS 7285 (Parts 1 and 2) and IS 8198.

9.6.2 *Pressurized Containers*

Containers used for water storage that are normally pressurized or that are pressurized when the system is activated, shall conform to the requirements of relevant standards.

9.6.3 Storage containers shall be located as close as possible to the protected hazard but in different fire compartment. It shall be possible to locate them in the same compartment provided they are not exposed to undue hazards.

9.6.4 Storage containers shall be located otherwise, fixed and/or manifolded as per the requirements specified in IS 15493 for clean agent systems.

9.7 Flow Switches

Flow switches shall be selected in such a way to detect flow from even a single mist nozzle. The nominal flow of activation of the flow switch shall, therefore, be not higher than 75 percent of the nominal flow of the smallest nozzle in the system operating at the rated pressure.

10 REVIEW, COMMISSIONING, ACCEPTANCE AND MAINTENANCE

10.1 General

Test for all systems shall comply with the following.

10.1.1 The completed system shall be reviewed and tested by qualified personnel to meet the approval of authorities concerned. Tests shall be conducted as part of the nozzle or system to address the compartment geometry, fire hazard and performance objectives, of the application specified. Tests shall be designed to replicate most or all of the application parameters associated with a given installation and any variations in these parameters shall be substituted using the worst case conditions. The listing of the system hardware shall be consistent with the intended system application. Tests shall be designed and conducted to stress the system in order to determine the working limits and parameters of the system, and to incorporate adequate severity to minimize the effects of test parameter variations. The results of the test shall be documented. The documentation shall be such that they can identify the working limits and parameters of the system, the fire hazard and the range of compartment parameters.

10.1.2 The results of the investigation shall identify, but not be limited to the following:

a) Fire protection objectives of the system (control, suppression or extinguishment), type of application (total flooding, zoned or local application), classes and types of fire (pool, running and spray), and types of fuel.
b) Protected enclosure volume limitations, allowable openings and ventilation conditions.
c) Maximum and minimum system flow rates, that is, the flow rate per unit volume or the flow rate per unit area as applicable to the specific risk.
d) Maximum and minimum system operating pressure, the nozzle operating range, the pump or cylinder operating pressure range, as applicable, and the pump inlet and outlet pressure and flow requirements.
e) Quality, temperature, quantity and duration of the water supply.
f) Nozzle performance characteristics including spray angle, droplet size and distribution, momentum and velocity.
g) Nozzle installation requirements including the maximum and minimum distances above the floor of the hazard and below the ceiling, nozzle spacing, orientation, minimum distance from walls and obstructions or shielding.
h) Activation device type or model number.
j) Specification of the distribution system and pump or storage cylinder.

10.2 Acceptance Criteria

10.2.1 The completed water mist system shall be commissioned in accordance with the check list given in Annex B and the system's performance shall be proven by the following methods:

a) All pipe work that could potentially contain water shall be hydrostatically tested to 1.5 times the normal working pressure for 10 min followed by testing for 110 min at system working pressure. Any loss shall be determined by a drop in gauge pressure or visible leakage.
b) For dry and pre-action systems, an air pressure leakage test shall be conducted at 3 bar pressure for 24 h in addition to routine hydraulic test.

NOTE — When cold weather does not allow testing with water, an interim air test shall be conducted. Any leakage observed during the test shall be corrected and system re-tested.

10.2.2 *Discharge Test*

a) Water mist systems shall be tested either by a full discharge test with recording of system and supply pressure, performance observation; or by a validation of pressure and flow of the water supply and free passage to all water mist nozzles by utilising alternative ways, provided this is allowed by the authorities concerned.
b) The minimum rate of flow shall be one of the following, whichever is greater:
    1) Hydraulically calculated water demand rate of the system; or
    2) Maximum rate of flow available to the system under fire conditions.

NOTE — On completion of the acceptance procedure, a certificate of compliance shall be issued by the installation contractor.

c) After full flow testing, all filters and strainers shall be inspected, cleaned and replaced, if necessary.
d) Where practicable, full flow tests of the system piping, using water, shall be made as a means of checking the nozzle layout, discharge patterns and any obstructions, determining the relationship between design criteria and actual performance, and ensuring against the clogging of the smaller piping and nozzles by foreign matter carried by the water.
e) Where practicable, the maximum number of systems that are expected to operate in case of fire shall be in full operation simultaneously when checking the adequacy and condition of the water supply.
f) All operating parts of the system shall be tested fully to ensure that they function as intended. The proper function and sequence of all devices shall be verified.

10.2.3 *Flushing or Cleaning of Piping*

a) System piping shall be flushed completely before connection is made to water mist piping. The flushing operation shall continue for sufficient time to ensure thorough cleaning.

b) Pipes shall be cleaned internally after preparation and before assembly as per the manufacturer's installation manual. Piping network shall be free of particulate matter and oil residue before the installation of the nozzles.

10.2.4 *Review of Mechanical Components*

The following review point shall be carried out for the components:

a) Piping system shall be inspected to determine that it is in compliance with the design and installation documents and hydraulic calculations.

b) Nozzles and pipe size shall be in accordance with system drawings.

c) Means of pipe size reduction and the attitudes of tees shall be checked for conformance to the design.

d) Piping joints, discharge nozzles, and piping supports shall be restrained to prevent unacceptable vertical or lateral movement during discharge.

e) Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.

f) Discharge nozzle shall be oriented in such a manner that optimum water mist application can be effected.

g) Ischarge nozzles, piping, and mounting brackets shall be installed in such a manner that they do not cause injury to personnel.

h) All water and gas storage containers shall be located in accordance with an approved set of system drawings.

j) All containers and mounting brackets shall be fastened in accordance with the manufacturer's requirements.

10.2.5 *Review of Electrical Components*

The electrical components also need periodic review as indicated below:

a) All wiring systems shall be checked for proper installation in conduit and in compliance with the approved drawings.

b) It shall be confirmed that a.c. wiring and d.c. wiring are not combined in a common conduit or raceway unless properly shielded and grounded.

c) All field circuits shall be confirmed to be free of ground faults and short circuits.

d) Where measuring field circuitry, the following shall apply:

   1) All electronic components, such as smoke and flame detectors or special electronic equipment for other detectors or their mounting bases, shall be removed.

   2) Jumpers shall be installed properly to prevent the possibility of damage within these devices.

   3) All components shall be replaced after measuring.

e) The detection devices shall be checked for proper type and location as specified on the system drawings.

f) The detectors shall be installed in a professional manner and in accordance with technical data regarding their installation and relevant clauses in IS 2189.

g) Manual pull stations shall be confirmed as accessible, accurately identified, and properly protected to prevent damage.

h) Design the system to be automatically actuated. Provide a method for manual actuation.

j) Automatically shut-off or close interlocked devices, such as exhaust fans or doors before operation of the water mist system

k) Ensure abort switches, if used, are of the 'dead man' type requiring constant manual pressure.

10.2.6 It is recommended to comply with following additional requirements:

a) Provide an adequate quantity of water and compressed gas (if applicable) to meet the demand. Ensure the quantity is adequate for the largest single hazard or group of hazards protected by one system distributed through the appropriate manifolded selector valve. If water discharge continues after the compressed gas supply has been exhausted, it is not effective for fire suppression.

b) Provide agent supply dependent on whether the water mist system is used as a special protection or primary protection system.

c) Water mist may be used as a special protection system when it is able to extinguish all of the fire scenarios for the hazard protected and where the installation has a limited agent supply. Double the agent quantity needed to extinguish the worse-case fire scenario or 10 min, whichever is greater.

10.3 System Maintenance

10.3.1 The responsible user shall maintain the water mist fire protection system. Maintenance shall be performed to keep the system equipment operable or to make repairs. As built system installation drawings, original acceptance test records, and device manufacturer's maintenance bulletins shall be retained to assist in the proper care of the system and its components.

10.3.2 Preventive maintenance, such as lubricating control valve stems, adjusting packing glands on valves and pumps, bleeding moisture and condensation from air compressors and air lines, and cleaning strainers shall be carried out specific maintenance activities, where applicable to the type of water mist system, shall be performed in accordance with the schedules provided in the installation and design manual.

10.3.3 Corrective maintenance includes, but is not limited to, replacing loaded, corroded or painted nozzles, replacing missing or loose pipe hangers, cleaning clogged fire pumps, replacing valve seats and gaskets, and restoring heat in areas subject to freezing temperatures where water-filled piping is installed.

10.3.4 Emergency maintenance includes, but is not limited to, repairs due to piping failures caused by freezing or impact damage, repairs to broken water mains and replacing.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
5 : 2007	Colours for ready mixed paints and enamels (*sixth revision*)
2189 : 2008	Code of practice for selection, installation and maintenance of automatic fire detection and alarm system (*fourth revision*)
7285	Refillable seamless steel gas cylinders
(Part 1) : 2004	Normalized steel cylinders
(Part 2) : 2004	Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa (112 kgf/mm^2)
8198 : 2004	Steel cylinders for compressed gases (atmospheric gases, hydrogen, high pressure liquefiable gases and dissolved acetylene gases) — Code of practice
15105 : 2002	Design and installation of fixed automatic sprinkler fire extinguishing systems — Code of practice
15325 : 2003	Code of practice for design and installation of fixed automatic high and medium velocity water spray system
15493 : 2015	Gaseous fire extinguishing systems — General requirements
SP 30 : 2011	National electric code 2011
IS/IEC 60947 (Part 1) : 2007	Low-voltage switchgear and controlgear: Part 1 General rules
IS/IEC 60947 (Part 2) : 2003	Low-voltage switchgear and controlgear: Part 2 Circuit breakers
IS/IEC 60947 (Part 3) : 2012	Low-voltage switchgear and controlgear: Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units (*first revision*)
IS/IEC 60947 (Part 4/ Sec 1) : 2012	Low-voltage switchgear and controlgear: Part 4 Contactors and motor-starters, Section 1 Electromechanical contactors and motors-starters
IS/IEC 60947 (Part 4/ Sec 2) : 2011	Low-voltage switchgear and controlgear: Part 4 Contactors and motor-starters, Section 2 a.c. semiconductor motor controllers and starters (*first revision*)
IS/IEC 60947 (Part 4/ Sec 3) : 2011	Low-voltage switchgear and controlgear: Part 4 Contactors and motor-starters, Section 3 a.c. semiconductor motor controllers and contactors for non-motor loads (*first revision*)
IS/IEC 60947 (Part 5/ Sec 1) : 2009	Low-vltage switchgear and controlgear: Part 5 Control circuit devices and switching elements, Section 1 Electromechanical control circuit devices (*first revision*)
IS/IEC 60947 (Part 5/ Sec 2) : 2007	Low-voltage switchgear and control gear: Part 5 Control circuit devices and switching elements, Section 2 Proximity switches

ANNEX B

(*Clause* 10.2.1)

COMMISSIONING CHECK LIST

Sl No.	**Visual Inspection**	**Clause Reference**	**Compliance Verified**	**Type of Test Carried out, if Applicable**	**Remark**
(1)	(2)	(3)	(4)	(5)	(6)
i)	Do the plans accurately illustrate the hazard configuration?	**7.7**			
ii)	Are all components of the system in compliance with this standard?	**7.9**			
iii)	Check all flow calculations and verify that the containers, piping and operational equipment are installed and sized in accordance with the plans	**7.7, 9, 12** and **15**			
iv)	Are dimensions of unclosable openings in accordance with the plans?	**7.7** and **8.1**			
v)	Check protected area for openings other than those in iv)	**7.7** and **9**			
vi)	Does the nameplate data on storage containers correlate with the submitted details?	**16.1.3**			
vii)	Check quantity and mass of containers	**10**			
viii)	Check protected area volume	**8**			
ix)	Check need for and adequate provisions of post-fire ventilation	**6**			
x)	Physically check the pipework. Are pipe joints sound and is pipework adequately secured?	**12.4**			
xi)	Ensure that storage containers are disconnected	—			
xii)	Perform a full functional check of system (by operation of detectors) auxiliary electrical shutdown function (for example, doors released, dampers shut, air-handlers shutdown, etc. (*see* NOTE 1)	**7.4, 8** and **13**			
xiii)	Ensure that any non-fire shutdown plant capable of affecting system performance is operating during the test	**7.4**			
xiv)	Ensure system release(s) operates correctly (*see* NOTE 2)	**13**			

Sl No.	Visual Inspection	Clause Reference	Compliance Verified	Type of Test Carried out, if Applicable	Remark
(1)	(2)	(3)	(4)	(5)	(6)
xv)	Activate each detector head or system in turn by employing heat, products of combustion, etc. Ensure each manual alarm point operates and transmits	—			
xvi)	Ensure that the detection and control equipment complies with configuration and operation	**13**			
xvii)	Ensure that visual and audible alarms operate	**13.4**			
xviii)	Ensure that each alarm registers on CIE and mimic panels, if any	**13.3**			
xix)	Check that air-handling plant shutdown relay is activated	**7.4** and **13.2**			
xx)	Where multiple alarms are required for system operation, ensure that first and subsequent level alarms operate, including audible and visual indications, auxiliary equipment, and gas released mechanisms, if installed	**13.4**			
xxi)	Check that directional values are fitted where required and ensure that they operate correctly	**4.7**, **5.4** and **12.2**			
xxii)	Reset the system and check all manual released devices	—			
xxiii)	Reconnect storage container. Ensure that all caps, plugs and locking pins are removed and that the system is left in an operable condition (*see* NOTE 3)	**14.5**			

NOTES:

1 The objective is to check that the entire system operates, while avoiding unwanted discharging of the system.

2 The objective is to determine that the system operation mechanism functions when required and does not function under any other circumstance.

3 This should always be the last commissioning function.

ANNEX C

(*Foreword*)

COMMITTEE COMPOSITION

Fire Fighting Sectional Committee, CED 22

Organization	*Representative(s)*
Ministry of Home Affairs, New Delhi	Shri D. K. Shami (***Chairman***)
Agni Controls, Chennai	Shri D. Balachandran
Airports Authority of India, New Delhi	Shri Subhash Kumar Shri P. K. Deshmukh (*Alternate*)
Bhabha Atomic Research Centre, Mumbai	Chief Fire Officer
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Central Public Works Department, New Delhi	Shri Chaitanya Kumar Verma Shri D. K. Tulani (*Alternate*)
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